

# Franck-Condon Factors, *r*-Centroids, Electronic Transition Moments, and Einstein Coefficients for Many Nitrogen and Oxygen Band Systems

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# Franck-Condon Factors, *r*-Centroids, Electronic Transition Moments, and Einstein Coefficients for Many Nitrogen and Oxygen Band Systems

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Air fluorescence models require accurate Franck-Condon factors and Einstein coefficients for analyzing the intensities of  $N_2$ ,  $N_2^+$ , and  $O_2^+$  emissions produced by electron bombardment of air, such as in the aurora, high-altitude nuclear explosions, and rocket-borne electron gun experiments. In our previous report, improved vibrational and rotational constants based on the latest available spectroscopic measurements for several excited and ionic states important in air fluorescence modeling were derived. These constants have been used in the present work to calculate band origins, Franck-Condon factors, and *r*-centroids for many band systems of nitrogen and oxygen. These results, together with electronic transition moments obtained from published papers or derived here from published emission data and measured upper-state lifetimes, have been used to compute Einstein coefficients by the *r*-centroid method. Einstein coefficients by integration of the product of the electronic transition moment function and vibrational wavefunctions have also been computed for comparison. For band systems involving "perturbed" electronic states, Einstein coefficients have been derived by simply normalizing published emission data to measured upper-state lifetimes. In this report, tables of band origin wave-lengths and wavenumbers, Franck-Condon factors, *r*-centroids, electronic transition moments, and Einstein coefficients are presented for 17  $N_2$ ,  $N_2^+$ , and  $O_2^+$  band systems. Plots of most of the electronic transition moment functions used in these calculations are also given. In addition, tables of Franck-Condon factors only are presented for 16 other band systems of nitrogen and oxygen, and tables of band wavelengths and Einstein coefficients are presented for 3 band systems having "perturbed" upper states.

Key words: air fluorescence; band origins; Einstein coefficients; electronic transition moments; Franck-Condon factors; improved calculations; molecular nitrogen; molecular oxygen; radiative transition parameters; *r* centroids.

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### 1. Introduction

Einstein coefficients (radiative transition probabilities) for molecular nitrogen and oxygen bands are useful for calculating the emission spectra produced by electron bombardment of air, such as occurs, for example, in the aurora (Meier, 1987), high-altitude nuclear explosions (Boquist and Snyder, 1967), and rocket-borne electron gun experiments (O'Neil *et al.*, 1978a; 1978b). Accurate values of these coefficients are required for predicting the intensities of  $N_2$ ,  $N_2^+$ , and  $O_2^+$  emissions, which dominate the air fluorescence spectrum. They are also useful for other applications, such as calculating the radiation from high-temperature air (Landshoff and Magee, 1969; Avilova *et al.*, 1969), and analyzing the emissions from gas discharges (Cramarossa *et al.*, 1974) and afterglows (Golde and Thrush, 1973).

It is possible to measure Einstein coefficients in the laboratory; however, because there are so many bands of interest, with wavelengths ranging from extreme ultraviolet to far infrared, it is impractical to measure them all

individually. Instead, simplifying theoretical relations can be combined with limited experimental data to calculate Einstein coefficients for the large number of bands required. Such calculations are often based on the *r*-centroid approximation (e.g., Nicholls and Stewart, 1962). Einstein coefficients of different bands in a given band system are related to the vibrational overlap integrals, or Franck-Condon factors, and to the electronic transition moment, which can be approximated as a function of the expectation value of the internuclear distance, or *r*-centroid. The latter function can be derived from measured transition probabilities or band strengths of a few of the bands in the system. Franck-Condon factors are also useful for calculating the branching ratios for populating various vibrational levels when an electronic state is excited from the ground state by electron impact. This is based on the close relationship between transition probabilities in electron impact at high energies and radiation absorption for optically-allowed transitions (Lassettre, 1965; Lassettre *et al.*, 1965).

It is also possible to derive electronic transition moments from quantum-mechanical calculations, without use of band strength measurements. Such calculations are difficult, but have very recently attained an accuracy comparable to that of many band intensity measurements. They usually cover a wider range of internuclear distances than is covered by the *r*-centroid method. Their accuracy can sometimes be increased by multiplying the calculated transition moment by a constant correction factor based on a measurement of one band intensity or radiative lifetime.

Many Einstein coefficients, Franck-Condon factors, and *r*-centroids for nitrogen and oxygen band systems have been published previously. In a monograph on the spectrum of molecular oxygen, Krupenie (1972) compiled from various sources and tabulated many of these quantities for several oxygen band systems, including the *A*-*X* and *b*-*a* band systems of  $O_2^+$ , and several ionization systems of  $O_2$ . In a similar monograph on molecular nitrogen, Lofthus and Krupenie (1977) compiled and presented many of these quantities for several band systems of  $N_2$  and  $N_2^+$ . More recently, Slanger (1986) tabulated Morse-potential Franck-Condon factors for the  $N_2 c_4-a$  band system. James *et al.* (1988) tabulated Morse-potential Franck-Condon factors for the  $O_2^+ A-X$  band system and  $O_2^+ A-O_2 X$  ionization system. Green *et al.* (1988) tabulated RKR Franck-Condon factors and *r*-centroids for the  $N_2 B-A$  band system. Piper *et al.* (1989) tabulated Einstein coefficients for the  $N_2 B-A$  band system, which they calculated from their measured electronic transition moment function. Marinelli *et al.* (1988) tabulated Einstein coefficients for the  $N_2 a-X$  and  $a-a'$  band systems; however, later measurements of the  $\bar{a}$  state lifetime by Marinelli *et al.* (1989) indicated that their  $a-X$  Einstein coefficients should be increased by about 35%. Ajello *et al.* (1989) tabulated Morse-potential Franck-Condon factors for the  $N_2 c_4-X$  band system, and RKR Franck-Condon factors for several  $N_2 b'-X$  bands. Allen and Lin (1989) listed both RKR and Morse-potential

Franck-Condon factors for a few  $N_2 c_4-X$  bands. And finally, Allen *et al.* (1990) tabulated both RKR and Morse-potential Franck-Condon factors for the  $N_2 x-a'$ ,  $y-a'$ , and  $y-w$  band systems.

However, the published literature falls far short of providing complete and accurate sets of radiative parameters for all of the band systems that contribute significantly to air fluorescence. In particular, values of Einstein coefficients and *r*-centroids are available for fewer than half of the band systems of interest. Moreover, many of the published values are based on older spectroscopic constants or radiative lifetimes that have been superseded by more recent measurements. In a previous report (Laher and Gilmore, 1991), the spectroscopic constants of the pertinent nitrogen and oxygen states were reviewed, and new constants for many of these states were derived. In the present work these improved values have been employed to calculate new RKR potential curves and, thence, improved Franck-Condon factors and *r*-centroids. Also, the available information on electronic transition moments has been examined, the best values determined or newly derived, and these used to calculate Einstein coefficients. The results from calculations employing both *r*-centroid and direct methods of computing Einstein coefficients are presented.

In addition, three band systems with "perturbed" upper electronic states are considered in this report. Einstein coefficients for these transitions cannot be calculated as simply as is possible for transitions involving unperturbed states. In these cases, the most practical alternative to a complex theoretical calculation is to derive Einstein coefficients from measured band intensities and radiative lifetimes. This is the approach that has been taken here.

## 2. Methods of Calculation

### 2.1. RKR Internuclear Potential Energy Functions

In the Rydberg-Klein-Rees (RKR) method of determining potential energy curves for diatomic molecules (Rydberg, 1931; Klein, 1932; Rees, 1947), the classical turning points are computed from experimental vibrational and rotational spectroscopic term values through the equations:

$$f(v) = \frac{\hbar}{2\pi\sqrt{2\mu}} \int_{-1/2}^v [G(v) - G(v')]^{-1/2} dv', \quad (1)$$

and

$$g(v) = \frac{2\pi\sqrt{2\mu}}{\hbar} \int_{-1/2}^v B_{v'} [G(v) - G(v')]^{-1/2} dv', \quad (2)$$

with the internuclear distances of the inner and outer turning points given by:

$$r_{\text{inner}}, r_{\text{outer}} = (f/g + f^2)^{1/2} \mp f. \quad (3)$$

In the above equations,  $h$  is Planck's constant,  $\mu$  is the reduced mass of the molecule, and  $G(v)$  and  $B_v$  are mathematical expressions involving tabulated spectroscopic constants which give the experimentally determined vibrational energy and rotational constant at each vibrational quantum number  $v$ . In order to maintain high accuracy and remove the singularity that occurs at  $v' = v$ , the above equations have been integrated using a 16 point Gauss-Jacobi quadrature (Stroud and Secrest, 1966), as detailed by Tellinghuisen (1972).

These integrations yield the turning points at the value of the potential energy function  $U(r)$  corresponding to the energy  $G(v)$ . As a result,  $U(r)$  is determined at unequally-spaced values of internuclear distance  $r$ . In order to use this potential to calculate wave functions, it is necessary to interpolate it to equally-spaced values of  $r$ . In addition, it may be necessary to extrapolate the potential beyond the region derived from experimental data. Frequently, the interpolation is done with a high-order Lagrange polynomial (Zare, 1964), which, although cumbersome and computationally expensive, is stable for interpolation. Functional forms for the repulsive and attractive potential segments may then be smoothly joined to the experimentally determined curve in order to extrapolate the potential energy into regions where the wave function becomes small. Typically the wave functions derived from the potential are not very sensitive to the choice of extrapolation segments used.

In the present work, an interpolation and extrapolation method based upon a Morse-type function has been used. This method has been found to yield results in excellent agreement with those produced by a seventh-order Lagrange interpolating polynomial, with a reduction in computation time by a factor of 3. The Morse potential function is given by:

$$U(r) = D_e \{1 - \exp[-\beta(r - r_e)]\}^2, \quad (4)$$

where  $D_e$  is the dissociation energy,  $\beta$  is a constant, and  $r_e$  is the equilibrium internuclear distance. Equation (4) can be inverted to yield an expression for the exponent:

$$L(r) = -\beta(r - r_e) = \ln[1 \pm \sqrt{U(r)/D_e}], \quad (5)$$

where the upper sign is for  $r < r_e$  and the lower for  $r > r_e$ . Substitution of the RKR values of  $U(r)$  in Eq. (5) yields a set of values for  $\beta$  and, hence, through Eq. (4), a set of Morse potentials, each of which passes through one of the RKR points and has the correct curve minimum and dissociation limit. If the entire RKR curve agreed with a Morse potential, these calculated Morse potentials would coincide, and  $L(r)$  would be a linear function of  $r$ . Due to deviations from the Morse potential, the calculated  $L(r)$  behavior is not exactly linear, but its variation is gradual enough that linear interpolation between successive RKR values provides excellent accuracy. Similarly, linear extrapolation of  $L(r)$  provides reasonable extensions of the RKR potential to somewhat larger and smaller internuclear separations.

For the calculations presented in this report, the molecular constants tabulated by Laher and Gilmore (1991) were used to compute  $r_e$ ,  $T_e$ ,  $G(v)$  and  $B_v$ . The dissociation energy,  $D_e$ , for each state was determined by subtracting  $T_e$  from the energy of the dissociation limit. For most of the states of  $N_2$  and  $N_2^+$ , and all of the states of  $O_2^+$ , this limit energy was calculated by adding the  $T_0$  and  $D^0$  values listed by Lofthus and Krupenie (1977) and Krupenie (1972), respectively. However, for two of the higher states of  $N_2$  and one of  $N_2^+$ , the listed  $D^0$  values correspond to the onset of predissociation due to the "avoided crossing" of another potential curve (see Herzberg, 1950, p. 296). In employing Eq. (5) to calculate a potential curve below the avoided crossing, it is better to use a  $D_e$  value based on the noninteracting "diabatic" curve that goes to a higher dissociation limit. The molecular orbital configurations of these three states (Lofthus and Krupenie, 1977) suggest that the appropriate limits and energies (in  $\text{cm}^{-1}$ ) are:  $N_2 C^3\Pi_u$ ,  $^4S^0 + 2s2p^4\ ^4P$ ; 166850;  $N_2 E^3\Sigma_g^+$ ,  $^4S^0 + 3s\ ^4P$ , 162054;  $N_2^+ 2p^3\ ^5S^0$ , 242725. Similarly for the  $N_2 D^3\Sigma_u^+$  state, whose dissociation energy is not listed by Lofthus and Krupenie, the appropriate limit and energy are  $^4S^0 + 3s\ ^4P$ , 162054.

## 2.2. Wave Functions, $r$ -Centroids, and Franck-Condon Factors

The RKR potential energy derived above was used in the radial Schrödinger equation to solve for the rotationless vibrational wavefunctions,  $\psi(r)$ , where  $r$  is the internuclear distance. The numerical method of solution of the radial Schrödinger equation has been described by Cooley (1961); it employs the Numerov (1933) method of integration. Cooley's procedure also uses an improved formula for the correction of trial eigenvalues, based upon the second-order iteration-variation method of Löwdin (1958). Since the accuracy of this predictor-corrector formula does not depend critically upon a small step size being used in the radial coordinate, relatively few potential energy steps (1024) were used in the integration. A brief description of the Cooley method as well as an assessment of its accuracy and numerical stability may be found in the work of Cashion (1963). Using the computed vibrational wavefunctions, the Franck-Condon factors,  $q_{v'v}$ , and  $r$ -centroids,  $\bar{r}_{v'v}$ , were then calculated from their defining integrals (Fraser 1954; Nicholls and Stewart, 1962):

$$q_{v'v} = \left[ \int \psi_v^* \psi_{v'} dr \right]^2 \quad (6)$$

$$\bar{r}_{v'v} = \int \psi_v^* r \psi_{v'} dr / \int \psi_v^* \psi_{v'} dr, \quad (7)$$

by Simpson's rule integration where the primes and double primes denote upper and lower states, respectively. Equation (7) shows that  $\bar{r}_{v'v}$  is a weighted mean of the internuclear distance for the  $(v'-v')$  band, with the weighting function  $\psi_v^* \psi_{v'}$ . However, unlike conventional

weighting functions,  $\psi_v^*, \psi_v$ , can change sign over the integration range. Consequently, the denominator of Eq. (7) can become very small even when the numerator is not so small, so that the  $r$ -centroid can become very large, lying beyond the range of  $r$  where the wavefunctions are appreciable. For similar reasons the  $r$ -centroid can also go negative. However, such large or negative values occur only when the denominator is quite small. In such a situation, the Franck-Condon factor, which equals the square of the denominator, is very small, and the band is correspondingly very weak and usually of little practical importance. Moreover, in such cases, the Franck-Condon factor and intensity often vary significantly with rotational quantum number, a variation which is conventionally neglected.

### 2.3. Electronic Transition Moments and Einstein Coefficients

A diatomic electronic-vibrational transition may be expressed as

$$2S'+1\Lambda' (v') \rightarrow 2S''+1\Lambda'' (v''), \quad (8)$$

where  $S$  is the spin quantum number, and  $\Lambda$  is the electronic angular momentum quantum number ( $\Lambda$  values of 0, 1, 2, ... are indicated by the state symbols  $\Sigma, \Pi, \Delta, \dots$ ).

In accordance with the definition established by Schadee (1978) and Whiting *et al.* (1980) for the electronic transition moment, the Einstein coefficient,  $A_{v'v''}$  (in  $s^{-1}$ ), for a transition in which  $S'=S''$  is related to the electronic transition moment,  $R_e(r)$  (in electric dipole moment atomic units), by

$$A_{v'v''} = (2.026 \times 10^{-6}) \frac{(2 - \delta_{0,\Lambda'} + \Lambda')}{(2 - \delta_{0,\Lambda''})} v_{v'v''}^3 \left[ \int \psi_v^* R_e(r) \psi_v dr \right]^2, \quad (9)$$

where  $v_{v'v''}$  is the band origin wavenumber (in  $\text{cm}^{-1}$ ) and  $\delta_{0,\Lambda}$  is the Kronecker delta, which equals 1 if  $\Lambda=0$  and equals 0 otherwise. For an electronic transition involving a change in spin, the corresponding relation is often more complicated, involving several independent transition moments (Whiting *et al.* 1973). However, only one such spin-forbidden transition has been observed in air fluorescence, the  $\text{N}_2 A^3\Sigma_u^+ - X^1\Sigma_g^+$  Vegard-Kaplan band system. For this system the relation is simple; the fraction involving the Kronecker delta in Eq. (9) is just replaced by 2/3.

If the transition moment function,  $R_e(r)$ , for a band system is known from quantum-mechanical calculations, the Einstein coefficients for the bands can be calculated from Eq. (9). If, however, only experimental band strengths for some of the bands are known, Eq. (9) must first be inverted to solve for  $R_e$  in terms of the band strengths. The derived  $R_e(r)$  can then be used to calculate the strengths or lifetimes of the other bands. The simplest method of performing this inversion is the  $r$ -centroid method

(Fraser, 1954; Nicholls and Stewart, 1962). This method can be derived from a power series expansion of  $R_e(r)$ :

$$R_e(r) = a + br + cr^2 + \dots \quad (10)$$

The integral in Eq. (9) can then be written

$$\begin{aligned} \int \psi_v^* R_e(r) \psi_v dr &= a \int \psi_v^* \psi_v dr + b \int \psi_v^* r \psi_v dr + c \int \psi_v^* r^2 \psi_v dr + \dots \\ &= q_{v'v''}^{1/2} [a + b \bar{r}_{v'v''} + c \bar{r}_{v'v''}^2 Y_{v'v''}^{(2)} + \dots], \end{aligned} \quad (11)$$

where

$$Y_{v'v''}^{(2)} = \frac{\int \psi_v^* r^2 \psi_v dr / \int \psi_v^* \psi_v dr}{\bar{r}_{v'v''}^2} = \frac{\bar{r}_{v'v''}^2}{\bar{r}_{v'v''}^2}. \quad (12)$$

For many band systems  $R_e(r)$  can be well approximated by either a constant or a linear function of  $r$ , at least over the range of  $r$  important for the stronger bands. In this case the  $cr^2$  term and higher terms in Eq. (10) can be dropped, and Eq. (11) becomes simply

$$\int \psi_v^* R_e(r) \psi_v dr = q_{v'v''}^{1/2} R_e(\bar{r}_{v'v''}). \quad (13)$$

This is the  $r$ -centroid approximation.

Even when  $R_e(r)$  is significantly nonlinear, Eq. (13) is a good approximation if the quantity  $Y_{v'v''}^{(2)}$  in Eqs. (11) and (12), and similar higher-order quantities,  $Y_{v'v''}^{(3)} = \bar{r}^3 / r^3$ , etc., are near unity. McCallum *et al.* (1972) have presented extensive tables of  $Y_{v'v''}^{(2)}$  and  $Y_{v'v''}^{(3)}$  for a number of  $\text{N}_2$  band systems. For all except a small fraction of the bands, these quantities are within 10 percent of unity. Those bands having greater deviations from unity all have Franck-Condon factors less than 0.03, so they are relatively weak. However, there is a general tendency for the  $Y_{v'v''}^{(3)}$  values to deviate more from unity than the  $Y_{v'v''}^{(2)}$  values, so if still higher-order terms in the power series representation of  $R_e(r)$  are important, the  $r$ -centroid approximation is likely to be less accurate.

A more direct method of determining the typical accuracy of the  $r$ -centroid approximation is to calculate both sides of Eq. (13) independently for a number of bands and band systems and compare the results. A small calculation of this type was made by Fraser (1954) for the  $\text{N}_2 B-A$  band system assuming three different exponential-power-law variations in  $R_e(r)$ . However, he treated only  $v'=0, v''=0-2$ , where the Franck-Condon factors are all greater than 0.16, so it is not surprising that he found that Eq. (13) was an excellent approximation.

In the course of the present work, we computed both sides of Eq. (13) for 15 band systems of  $\text{N}_2$  and  $\text{N}_2^+$  and 2 band systems of  $\text{O}_2^+$ , many with  $v' v''=0-21$ . Our results show that the  $r$ -centroid approximation is generally accurate for the stronger bands in a band system which are usually the bands whose intensities can be most accurately measured experimentally. This justifies the standard  $r$ -centroid method of deducing  $R_e(r)$  from band intensity measurements [e.g., Hartmann and Johnson

(1978); Piper *et al.* (1989)]. Briefly,  $R_e(r)$  is replaced by  $R_e(\bar{r}_{v'v'})$  and Eq. (9) is rearranged to give

$$R_e(\bar{r}_{v'v'}) = \left[ \frac{\text{const.} \times A_{v'v'}}{v_{v'v'}^3 Q_{v'v'}} \right]^{1/2}, \quad (14)$$

where the constant can be obtained from Eq. (9). Sometimes, absolute values of the Einstein coefficients,  $A_{v'v'}$ , can be obtained from band absorption measurements utilizing the well-known relationship between absorption and emission coefficients or from emission measurements if the population of the emitting level can be determined by other means. More often, emission measurements give only relative values of  $A_{v'v'}$  and, hence, of  $R_e(\bar{r}_{v'v'})$ . These relative values are placed on an absolute scale by a measurement of the radiative lifetime of one of the emitting levels. The resulting values then determine the function  $R_e(\bar{r})$  with an accuracy that is usually limited only by the accuracy of the band intensity measurements and the number and range of the  $\bar{r}_{v'v'}$  values covered, rather than by the accuracy of the  $r$ -centroid approximation. In the present work, this method of deriving transition moments has been utilized for a few band systems for which published results are either unavailable or have been superseded by better intensity measurements.

#### 2.4. Treatment of Transitions Involving "Perturbed" Electronic States

Significant fluorescent radiation is known to be emitted by some high-lying states of  $N_2$  that have irregularly-spaced vibrational levels due to strong perturbations by nearby states of the same type (Herzberg, 1950). The effects of such perturbations on the vibrational and rotational levels of several high  $N_2$  states are illustrated in, for example, a paper by Carroll *et al.* (1970). These perturbations also cause irregularities in the intensities of the various bands, as shown, for example, by the recent extensive measurements of Ajello *et al.* (1989) on the  $N_2 c_4'-X$  and  $b'-X$  bands.

When two or more nearby electronic states of the same type interact strongly, it is possible to treat the resulting vibrational and rotational levels as mixtures of two or more "deperturbed" or "diabatic" electronic states. This has been done by Stahel *et al.* (1983) for three  $^1\Sigma^+$  and three  $^1\Pi_u$  states of  $N_2$  lying in the 12–14 eV region. In such situations, the proportions of the mixture vary with the vibrational level, so the conventional Born-Oppenheimer separation of electronic and nuclear motion is no longer valid. Consequently, the concept of an electronic transition moment as a function of internuclear distance is no longer applicable. It is still possible, in principle, to calculate the intensities of the bands in a band system using a coupled-state approach, as used by Stahel *et al.* However, the computations become quite complex even when just two or three coupled states are involved. The perturbed  $N_2$  states of present interest lie in an energy region where, as one goes to higher vibrational levels,

more and more coupled states must be included in the calculation.

In the present situation, the most practical method for deriving the Einstein coefficients of bands involving perturbed states is to use measured relative emission intensities normalized by radiative lifetime measurements or absolute absorption measurements. This method has been applied here to the  $N_2 b-X$ ,  $c_4'-X$ , and  $c_4'-a$  band systems. It should be noted, however, that the strength of a perturbation can change with the rotational level in a given vibrational level. Hence, the Einstein coefficients of the individual rotational lines in a perturbed band may differ. Consequently, the mean Einstein coefficient for a perturbed band may vary with temperature since changing the temperature changes the relative contributions of the different rotational lines in a band.

### 3. Results for Electronic Transition Moments

Electronic transition moment functions for many of the  $N_2$ ,  $N_2^+$ , and  $O_2^+$  band systems considered in this report have been published or may be derived from published data using the method described in Sec. 2.3. Some of these band systems have been studied extensively, while for others little information is available. In the present work, an effort has been made to identify the most accurate electronic transition moments from the choices available; usually this involved selecting the most recent work. The recent advances in the quantum-mechanical calculation of diatomic dipole moments are demonstrated by the selection of such theoretical values as the best available values for eleven of the band systems treated, while values derived by the  $r$ -centroid method were selected for only four systems.

The best available  $R_e(r)$  data for most of the band systems treated are plotted in Figs. 1 through 13. Some of these figures also include, for comparison, other data not used in the subsequent calculations because they are known to be or appear to be less accurate than the data used. No figures are presented for two band systems for which similar figures in the original references are adequate, or for two band systems where no information on the variation of  $R_e$  with  $r$  is available.

As a convenience in making subsequent calculations of Einstein coefficients, we have derived mathematical fits to the preferred transition moments, of the form

$$R_e(r) = a + br + cr^2 + d \exp[-f(r - g)^2], \quad (15)$$

where  $a, \dots, g$  are constant coefficients,  $R_e(r)$  is in electric dipole moment atomic units, and  $r$  is in Å. These units are consistent with Eq. (9) for computing Einstein coefficients in units of  $s^{-1}$ . Our fits are indicated and plotted in Figs. 1–13, and their coefficients are also listed in Table 1. The dipole moment functions for over half of the band systems treated could be satisfactorily fit with just a Gaussian term, i.e., the last term in Eq. (15). This expres-

sion has the advantage that it remains bounded everywhere and approaches zero for large values of  $r$ , which is known theoretically to be the correct behavior for most of the transitions considered. The dipole moment functions of the remaining band systems were fit with constant, linear, or quadratic expressions, corresponding to the first three terms on the right-hand side of Eq. (15), except for the  $O_2^+ A-X$  system, where a constant plus a Gaussian term was found necessary to obtain a good fit. Generally, in the ranges of  $r$  of practical interest, all of the fits appear to be essentially as accurate as the basic data that they fit.

Figures 1–13 and Table 1 are generally self-explanatory, except for one  $N_2^+$  and two  $O_2^+$  band systems. For the  $N_2^+ A-X$  band system, Fig. 9 shows two fairly recent quantum-mechanical results, and one semi-empirical curve deduced by Gattigner and Vallance Jones (1981) from measured relative band intensities, using the  $r$ -centroid method. The two theoretical  $R_e(r)$  functions have similar shapes and agree within 10 percent. Probably the more recent one, from Langhoff *et al.* (1987), is more accurate. The semi-empirical curve was derived only over a limited range of  $r$ , and has a different shape, which gives unreasonable values of  $R_e(r)$  if extrapolated very far. Gattigner and Vallance Jones' Fig. 4 shows that this curve fits their data points quite well. However, when their data are corrected for the improved Franck-Condon factors calculated in the present work, and additional points are added from their tables and references, the data become more scattered, and do not fit their curve as well as they do the theoretical curves.

For the  $O_2^+ A-X$  and  $b-a$  band systems, the recent quantum-mechanical results of Blomberg and Liu (1988) for both systems, and of Langhoff *et al.* (1989) for the latter system, appear to be quite accurate. This conclusion is supported by the excellent agreement between the two calculations for the  $b-a$  system, as shown in Fig. 13. Blomberg and Liu's results for the  $A-X$  system also agree reasonably well with the results of the somewhat more-approximate calculations of Wetmore *et al.* (1984) (see Fig. 12). Accordingly, the most recent theoretical results have been fit, as shown in Figs. 12–13 and Table 1, for use in our subsequent calculations.

A semi-empirical  $A-X$  curve deduced by Erman and Larsson (1977) from their measured lifetimes for  $A(v=0-7)$  is also included in Fig. 12. This curve differs significantly from the two theoretical curves, particularly at large internuclear separations, where the theoretical curves approach a linear variation, as expected theoretically for this transition. Moreover, using Erman and Larsson's curve, we calculated  $A$ -state lifetimes about 20 percent shorter than they measured. Erman and Larsson also presented a transition moment curve for the  $b-a$  system, based on their measured lifetimes for  $b(v=0-7)$ . This curve has not been included in our Fig. 13 because later measurements by Moseley *et al.* (1979) show that the higher levels,  $b(v>3)$ , have very short lifetimes due to predissociation, and all emissions observed by Erman and Larsson originated from  $b(v=0-3)$ . This

correction, combined with Erman and Larsson's listing of  $b$ -state lifetimes that increase by 22 percent from  $v=3$  to " $v=7$ ," also indicates that their accuracy estimate of about  $\pm 7$  percent is overly optimistic.

In addition, we made an attempt to apply the  $r$ -centroid method to the recent relative intensity measurements on the  $O_2^+ A-X$  bands by Schappe *et al.* (1988). However, the relative  $R_e(r)$  values derived from their published intensities were widely scattered. Further study suggested that they probably had a bigger problem with overlapping bands than they assumed. For example, the (0–6) and (4–8) bands are nearly coincident, and so are the (0–7) and (6–10) bands, but Schappe *et al.* attributed the measured intensities entirely to the first band of each pair.

#### 4. Band-Array Results

In this section, tables of calculated radiative transition parameters are presented for the 38 band systems considered in this report. Tables 2 through 18 give a complete set of radiative transition parameters for 17  $N_2$ ,  $N_2^+$ , and  $O_2^+$  band systems that are important in emission. With the exception of Tables 6, 11, and 12, these tables include seven quantities for each  $v'-v''$  band; they are (as ordered in the tables):

1. Band origin wavelength,  $\lambda_{v,v''}$  ( $\mu\text{m}$ );
2. Band origin wavenumber,  $\nu_{v,v''}$  ( $\text{cm}^{-1}$ );
3. Franck-Condon factor,  $q_{v,v''}$ ;
4.  $r$ -centroid,  $\bar{r}_{v,v''}$  ( $\text{\AA}$ );
5. Electronic transition moment,  $R_e(\bar{r}_{v,v''})$  (electric dipole moment atomic units);
6. Einstein coefficient,  $A_{v,v''}$  ( $\text{s}^{-1}$ ), calculated by the  $r$ -centroid method;
7. Einstein coefficient,  $A_{v,v''}$  ( $\text{s}^{-1}$ ), calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

The last two items are Einstein coefficients calculated by the  $r$ -centroid approximation and by direct integration. Since the latter is the more accurate of the two values, it is placed at the end of the list so that it can be read from the tables more easily. In Tables 6, 11, and 12, item 6 has been omitted. This is because these three band systems have constant  $R_e(r)$  functions, and, as shown in Sec. 2, the  $r$ -centroid approximation is exact for  $R_e(r)$  functions that are constant or vary linearly with internuclear distance. Thus, the two different methods of calculating Einstein coefficients yield the same result for these cases, as we have verified numerically for many bands in these three systems, as well as for a test case involving a linear variation.

For more than half of the band systems in Tables 2–18, radiative transition parameters are presented for  $v'$ ,  $v''=0-21$ . The exceptions include the band systems that involve the  $N_2 w^1\Delta_u$ ,  $C^3\Pi_u$ ,  $E^3\Sigma_g^+$ , and  $D^3\Sigma_u^+$  states, for which the available spectroscopic data are insufficient to permit reliable extrapolation to  $v=21$  (see Laher and Gilmore, 1991). In addition, results for the  $N_2^+ B^2\Sigma_u^+$ —

$X^2\Sigma_g^+$  system are limited to  $v' = 0 - 10$ , since the unusual behavior of the energy levels and potential curve of the  $B$  state prevent an adequate fit by the usual spectroscopic power series beyond  $v = 8$  or 10 (Laher and Gilmore, 1991). It would be possible to extend the present  $B-X$  calculations to higher vibrational levels by using a numerical RKR method, but since these levels are not significant in air fluorescence, this was not done.

For some of the bands in Tables 2-18, the wavelengths, wavenumbers, and Einstein coefficients have negative signs in front of their numerical values. This is to indicate that the transition is reversed. The  $N_2 B-A$  ( $0-8$ ) band at  $8.85 \mu\text{m}$  in Table 3 is an example. Since the  $A$  ( $v''=8$ ) state is higher in energy than the  $B$  ( $v'=0$ ) state, the transition proceeds from the  $A$  state to the  $B$  state. Such cases are known as reverse bands.

The calculated strengths of bands with small Franck-Condon factors are often less accurate than those with larger Franck-Condon factors. Accordingly, in Tables 2-18, the Einstein coefficients calculated by direct integration are marked with asterisks if the corresponding Franck-Condon factors are less than 0.01. There are two situations in which small Franck-Condon factors arise. The first is when the wavefunctions of the upper and lower states overlap very little; in this case, the calculated band strength is usually quite accurate. The second is when the wavefunctions do overlap but, because of a near cancellation between similar contributions of positive and negative values of  $\psi_u^*\psi_v$ , the resulting overlap integral is small. In this case, the overlap integral is sensitive to small variations in the potential energy curves, especially for high vibrational levels, and the resulting Franck-Condon factor may not be very accurate.

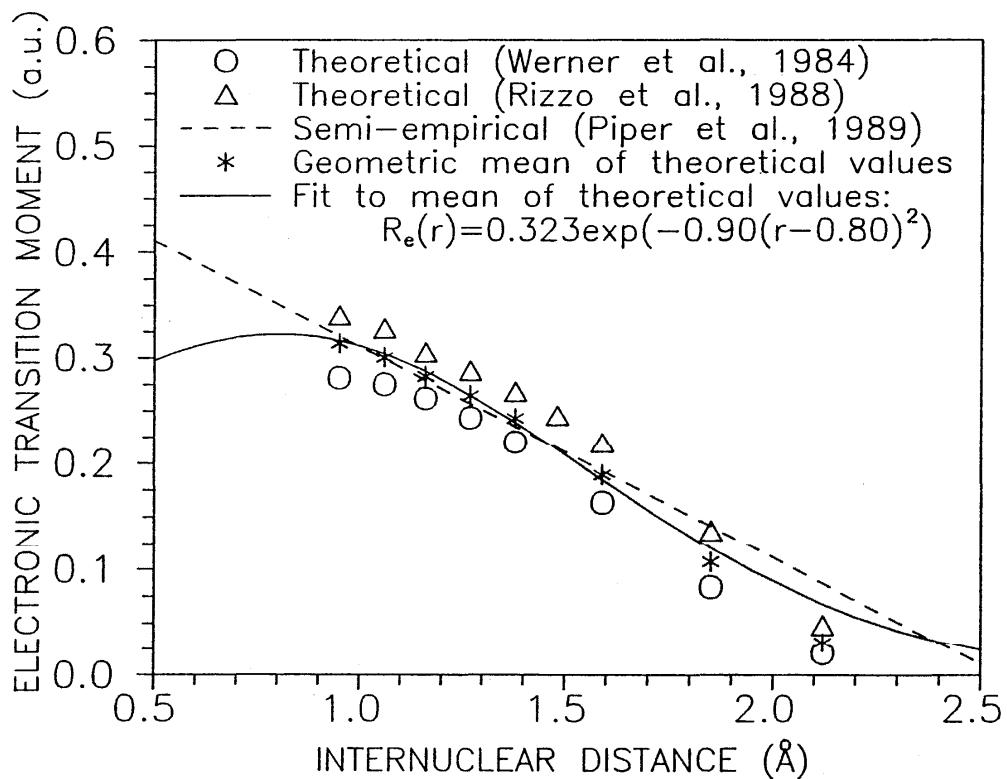
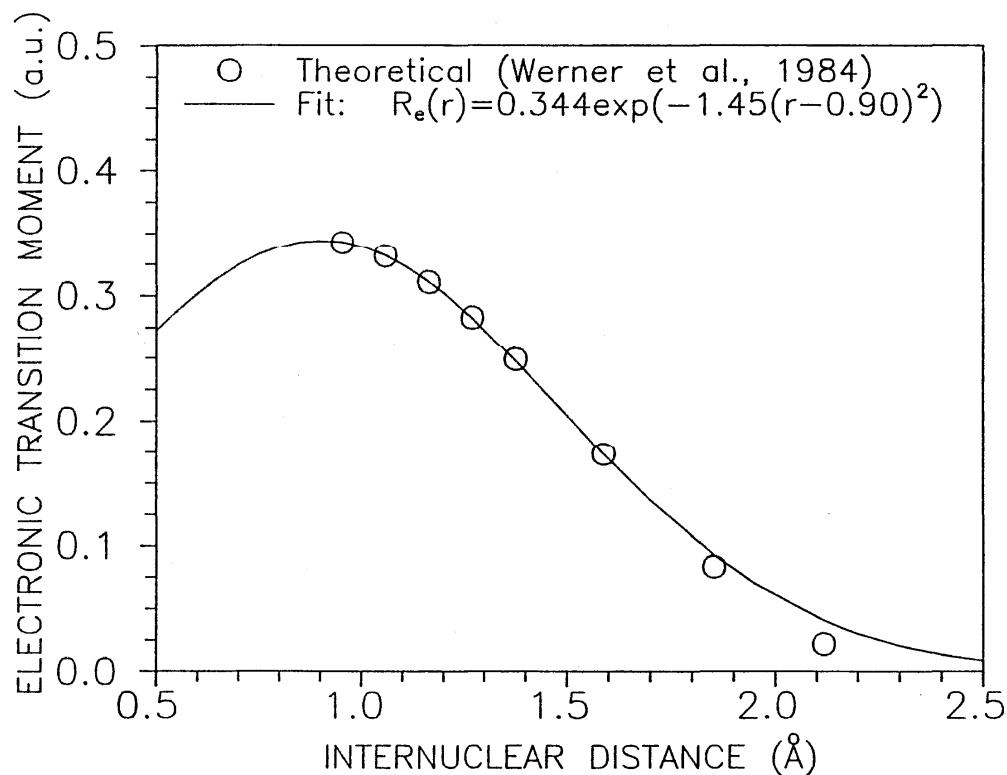
It is also interesting to note for which bands in the tables the Einstein coefficients calculated by the two methods disagree significantly. Accordingly, when the two values differ by more than 10%, the  $r$ -centroid value in the tables has been enclosed in parentheses. Such disagreement tends to occur when  $R_e(r)$  is significantly nonlinear and the Franck-Condon factor is small.

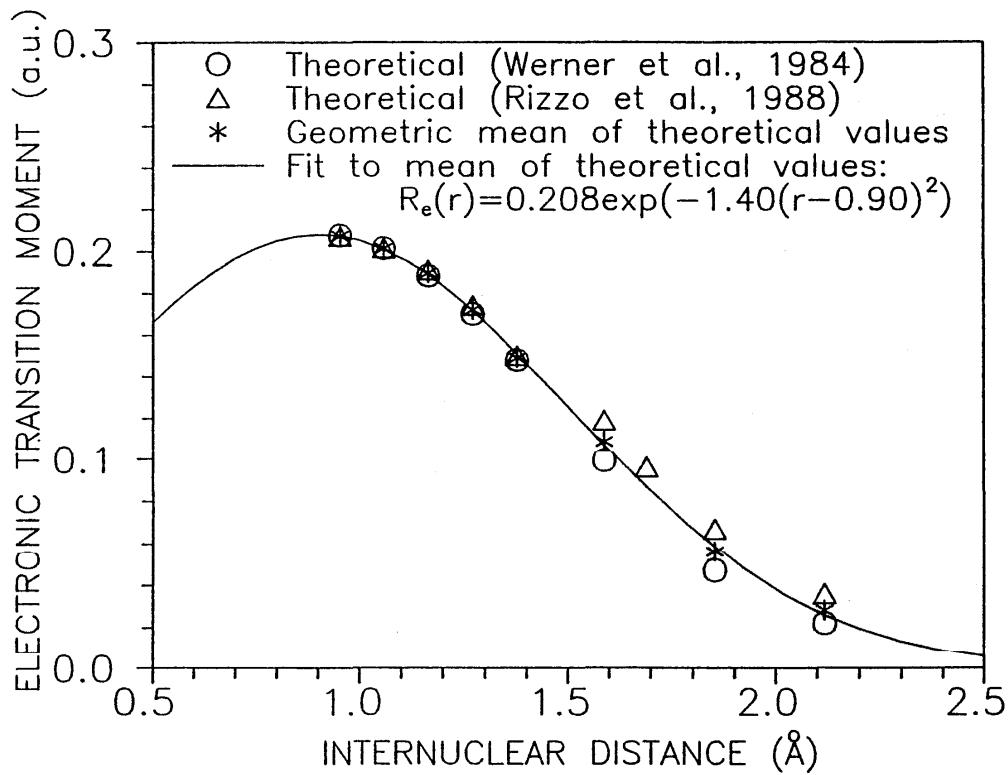
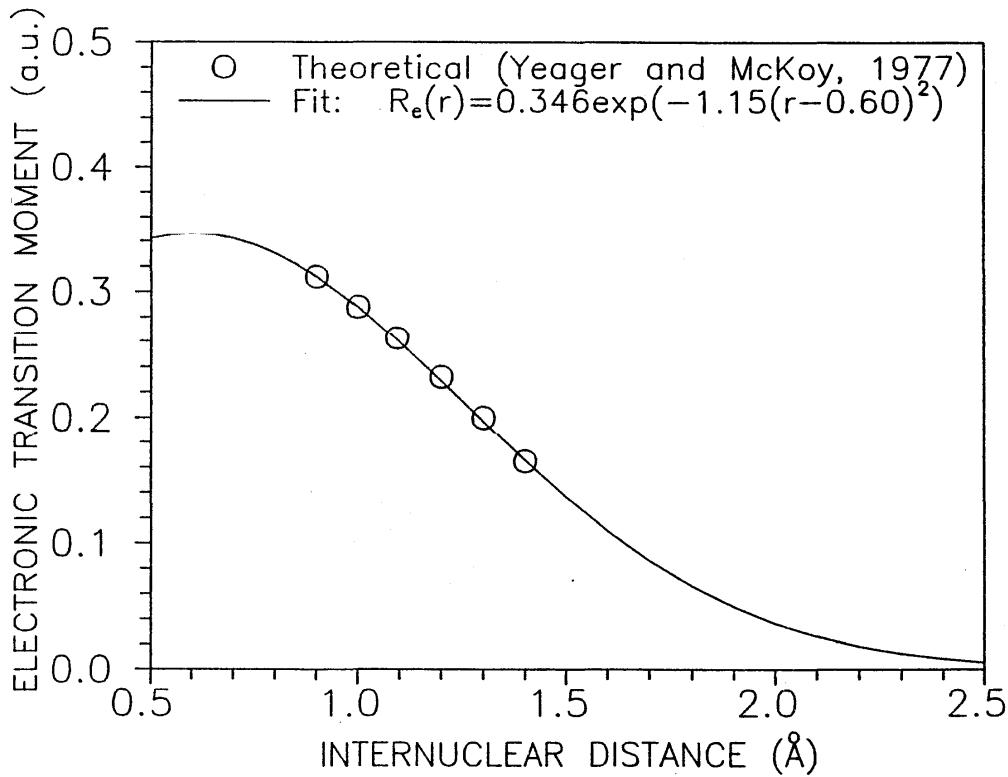
The radiative lifetimes of 14  $N_2$ ,  $N_2^+$ , and  $O_2^+$  states have also been calculated and are presented in Table 19

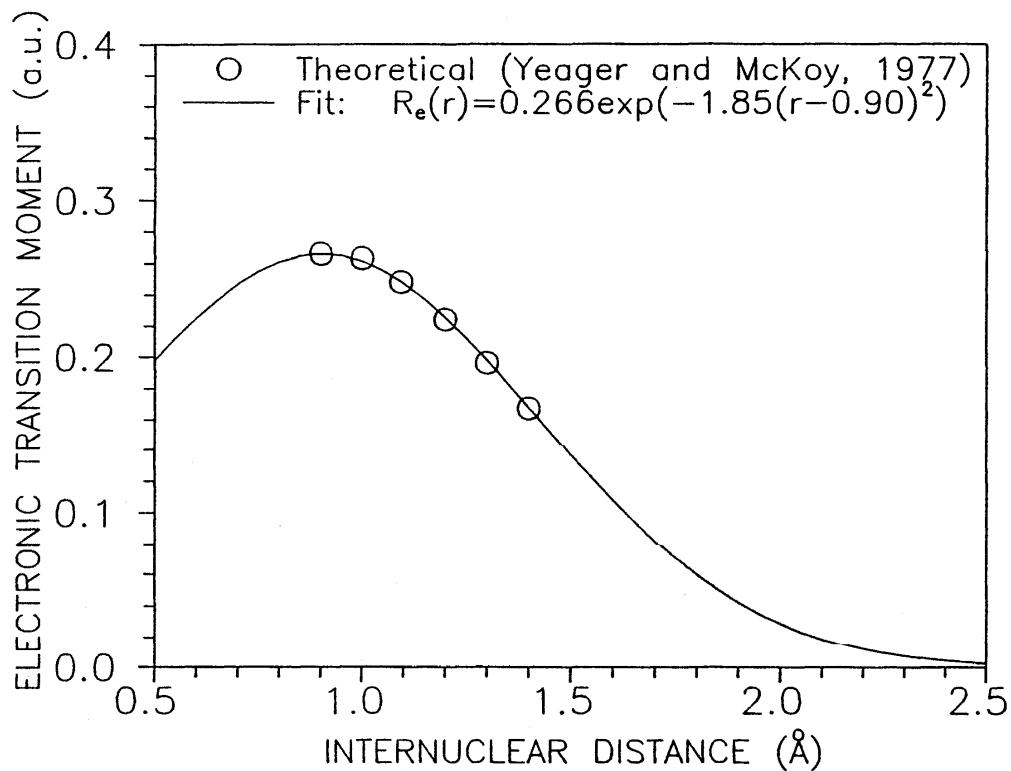
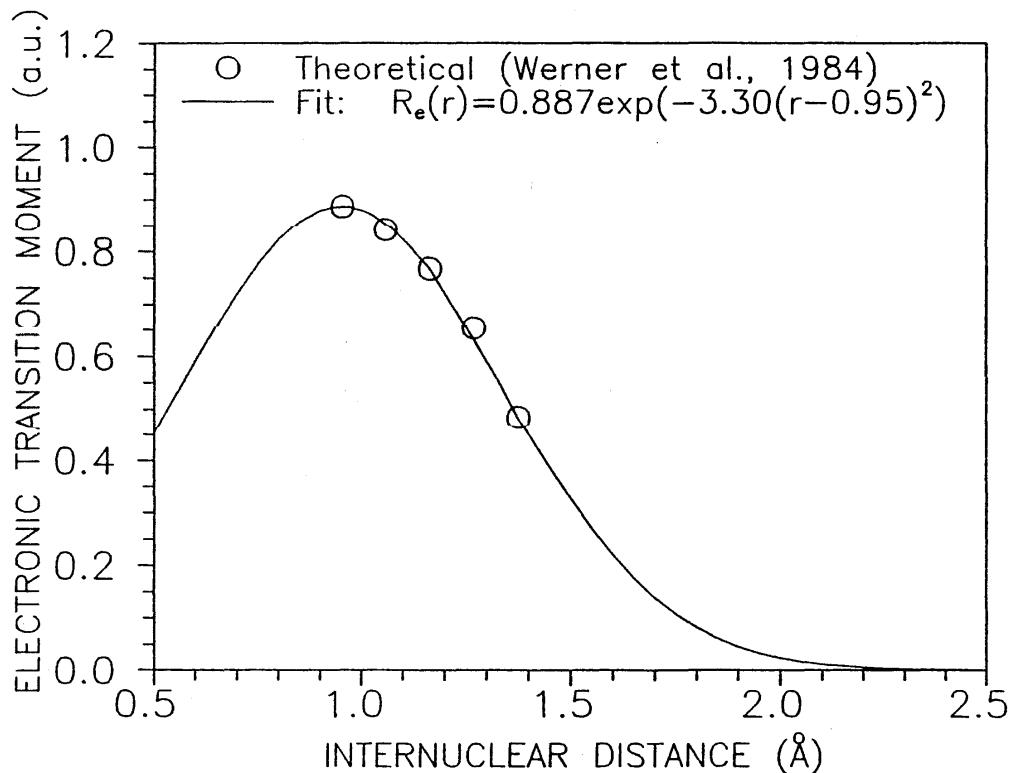
as a function of vibrational level. These quantities were obtained by taking the inverse of the sum of the Einstein coefficients (calculated by direct integration) for transitions from a given upper level to all possible lower levels, which may include more than one electronic state. For example, the radiative lifetime for a given  $v'$  of the  $N_2 A$  state was found by summing over  $v''$  all  $A_{v',v''}$  values for the  $A-X$  and  $B-A$  reverse band systems. The calculated lifetimes are generally in good agreement with the best available measurements, which can be verified by consulting the references given in Table 1. It should be noted, however, that radiative lifetimes for most of the levels listed in Table 19 have never been measured.

Tables 20 through 35 present tables of Franck-Condon factors for transitions between the upper states covered in the previous tables and the ground state, except for the  $N_2 A-X$  and  $a-X$  band systems, where Franck-Condon factors have already been presented in Tables 2 and 6. Eight of these tables cover  $N_2$  band systems for which insufficient information is available to calculate accurate Einstein coefficients, generally because they are very weak ("forbidden") transitions. In addition, eight nitrogen and oxygen ionization systems are included for application to photoionization and electron-impact ionization problems. The Franck-Condon factors presented in these tables are generally more accurate than those in previously published work because the RKR potential energy curves used in the present calculations are based on spectroscopic constants that are valid to higher vibrational levels.

Tables 36 through 38 cover three  $N_2$  band systems with perturbed upper states. As discussed in Sec. 2.4, perturbations involve mixing between electronic states, so the relations derived earlier for Franck-Condon factors, Einstein coefficients, etc., are no longer applicable. Consequently, Tables 36-38 simply list band origin or band head wavelengths derived from spectroscopic measurements, and Einstein coefficients derived from measurements of absolute absorption band intensities, relative emission band intensities and upper-state lifetimes. The sources and limitations of the basic data are indicated on the tables.

FIG. 1. Electronic transition moment data and fit for the  $\text{N}_2 \text{B} \ ^3\Pi_g - \text{A} \ ^3\Sigma_u^+$  band system.FIG. 2. Electronic transition moment data and fit for the  $\text{N}_2 \text{W} \ ^3\Delta_u - \text{B} \ ^3\Pi_g$  band system.

FIG. 3. Electronic transition moment data and fit for the  $\text{N}_2 \text{B}' \ ^3\Sigma^- - \text{B} \ ^3\Pi_g$  band system.FIG. 4. Electronic transition moment data and fit for the  $\text{N}_2 \text{a} \ ^1\Pi_g - \text{a}' \ ^1\Sigma^-$  band system.

FIG. 5. Electronic transition moment data and fit for the  $\text{N}_2 \text{ w } ^1\Delta_u - \text{a } ^1\Pi_g$  band system.FIG. 6. Electronic transition moment data and fit for the  $\text{N}_2 \text{ C } ^3\Delta_u - \text{B } ^3\Pi_g$  band system.

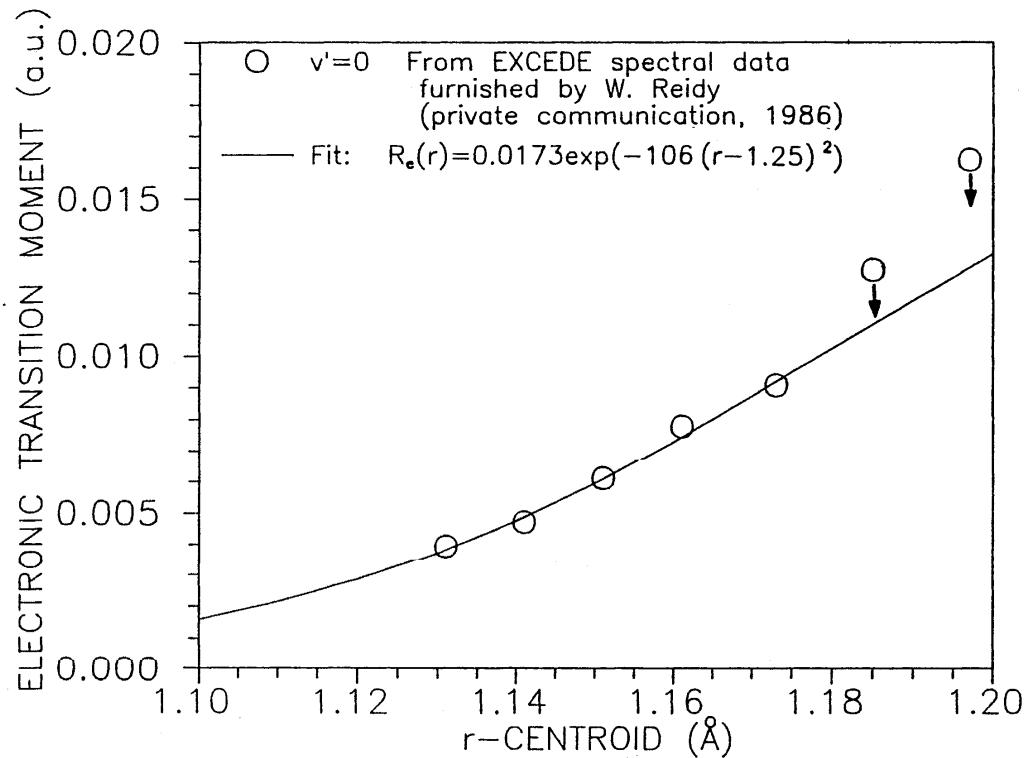


FIG. 7. Electronic transition moment data and fit for the  $N_2 E\ 3\Sigma_g^+ - A\ 3\Sigma_u^+$  band system.

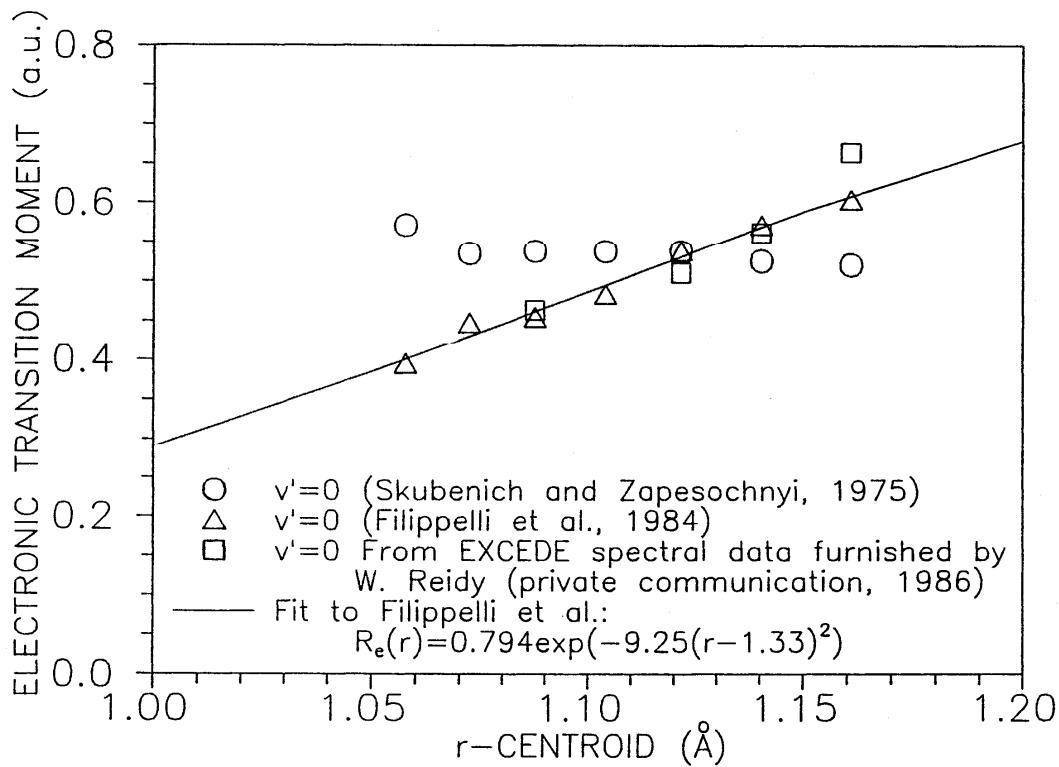
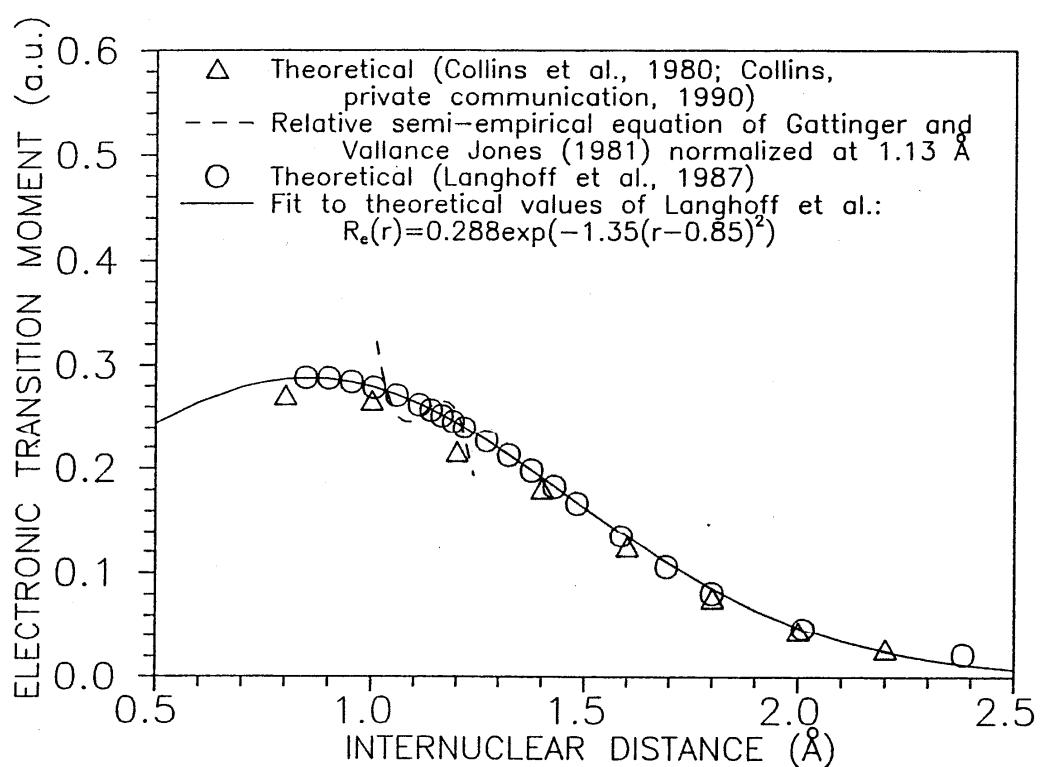
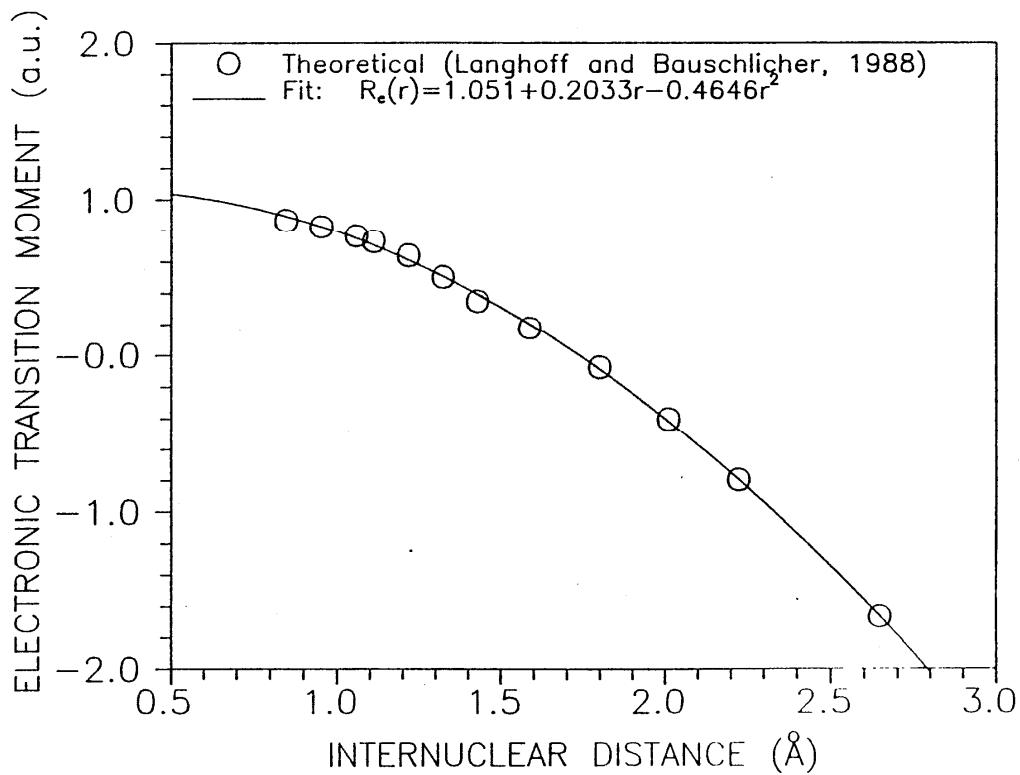
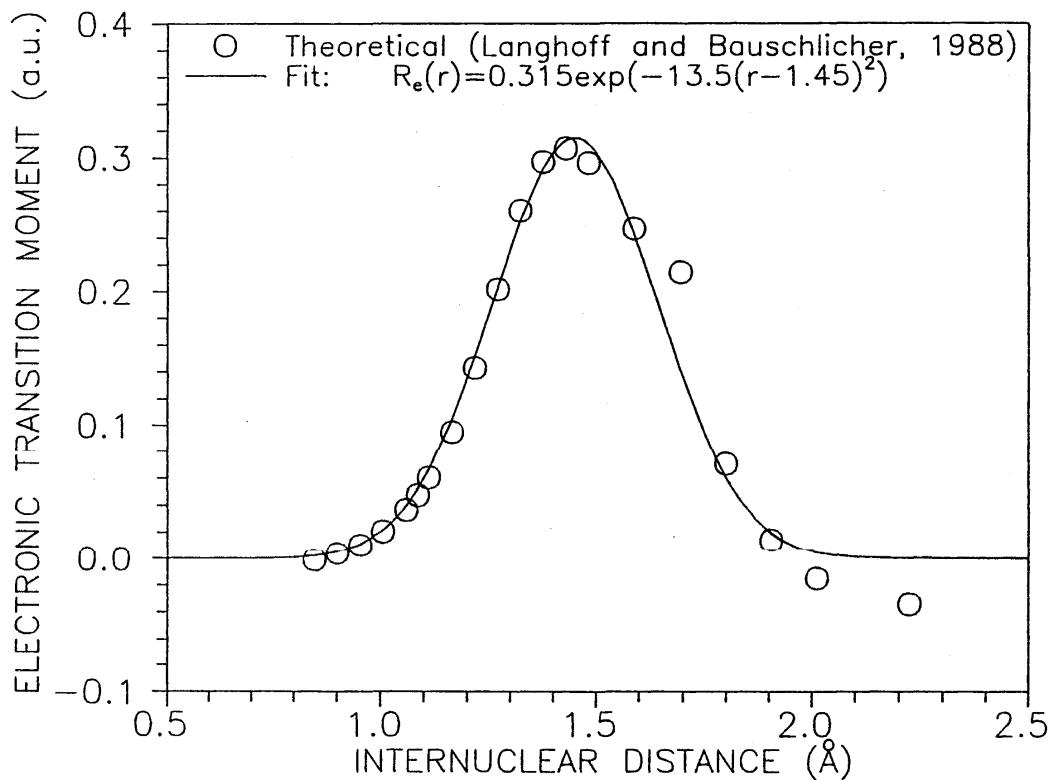
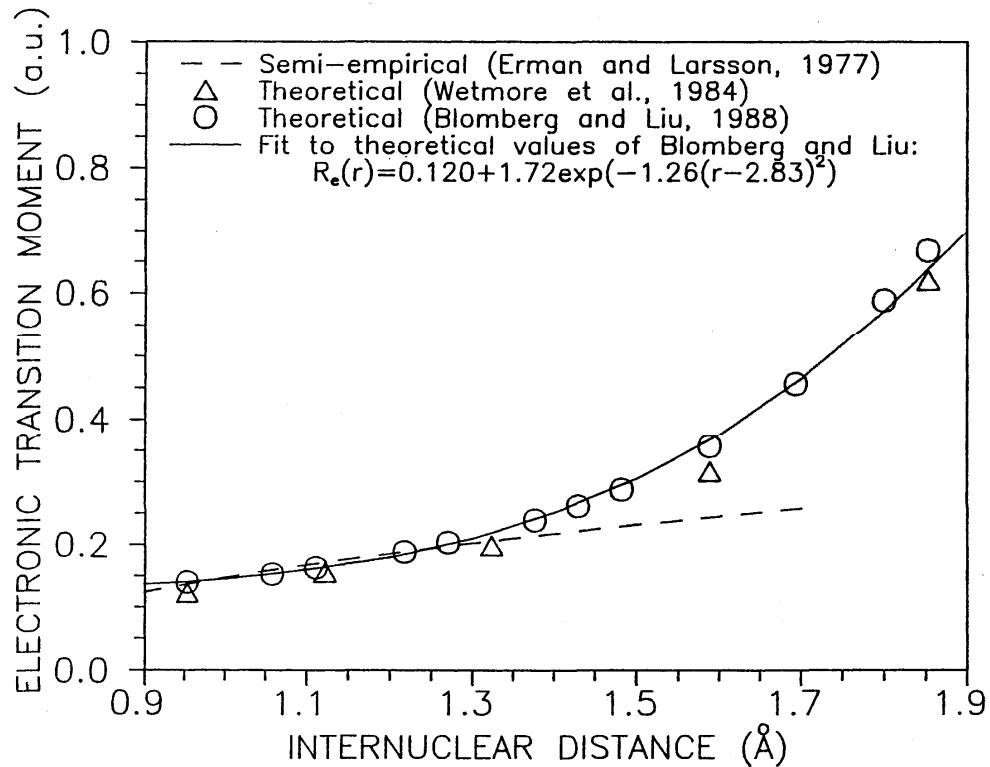


FIG. 8. Electronic transition moment data and fit for the  $N_2 D\ 3\Sigma_u^+ - B\ 3\Pi_g$  band system.

FIG. 9. Electronic transition moment data and fit for the  $\text{N}_2^+ A\ 2\Pi_u - X\ 2\Sigma_g^+$  band system.FIG. 10. Electronic transition moment data and fit for the  $\text{N}_2^+ B\ 2\Sigma_u^+ - X\ 2\Sigma_g^+$  band system.

FIG. 11. Electronic transition moment data and fit for the  $\text{N}_2\text{C}$   $^2\Sigma_u^+$  -  $X$   $^2\Sigma_g^+$  band system.FIG. 12. Electronic transition moment data and fit for the  $\text{O}_2\text{A}$   $^2\Pi_u$  -  $X$   $^2\Pi_g$  band system.

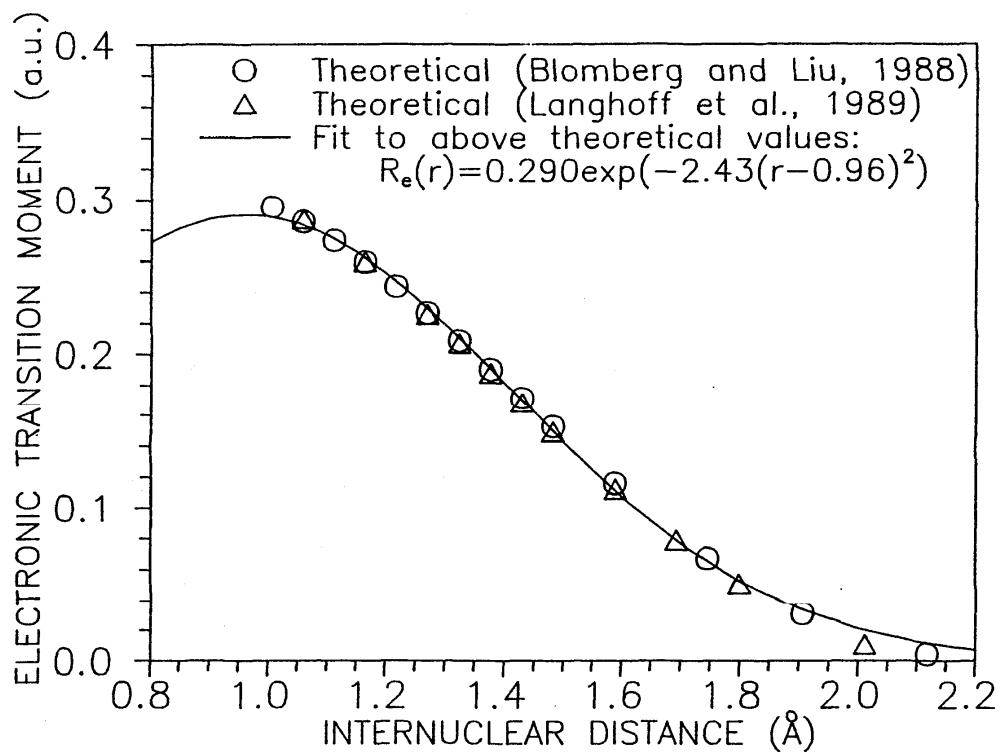
FIG. 13. Electronic transition moment data and fit for the  $\text{O}_2^+ b\ ⁴\Sigma^- - a\ ⁴\Pi_u$  band system.

Table 1. Coefficients of analytic fits to the electronic transition moments of N<sub>2</sub>, N<sub>2</sub><sup>+</sup>, and O<sub>2</sub><sup>+</sup> band systems.

$$R_e(r) = a + br + cr^2 + d \exp[-f(r - g)^2] \quad (R_e \text{ is in electric dipole moment atomic units; } r \text{ is in } \text{\AA}.)$$

| Band system  | <i>a</i> | <i>b</i> | <i>c</i> | <i>d</i> | <i>f</i> | <i>g</i> | References   |
|--|----------|----------|----------|----------|----------|----------|--|
| N <sub>2</sub> <i>A</i> <sup>3</sup> Sigma <sub>u</sub> <sup>+</sup> - <i>X</i> <sup>1</sup> Sigma <sub>g</sub> <sup>+</sup> | 0.00119  | -0.00117 | 0.000139 |          |          |          | Shemansky (1969a), renormalized to give mean Einstein coefficients, averaged over substates.   |
| <i>B</i> <sup>3</sup> Pi <sub>g</sub> - <i>A</i> <sup>3</sup> Sigma <sub>u</sub> <sup>+</sup>                                |          |          |          | 0.323    | 0.90     | 0.80     | Fit to geometric mean of theoretical values of Werner <i>et al.</i> (1984) and Rizzo <i>et al.</i> (1988) (see Fig. 1).  |
| <i>W</i> <sup>3</sup> Delta <sub>u</sub> - <i>B</i> <sup>3</sup> Pi <sub>g</sub>   |          |          |          | 0.344    | 1.45     | 0.90     | Fit to theoretical values of Werner <i>et al.</i> (1984) (see Fig. 2).   |
| <i>B'</i> <sup>3</sup> Sigma <sub>u</sub> <sup>-</sup> - <i>B</i> <sup>3</sup> Pi <sub>g</sub>                               |          |          |          | 0.208    | 1.40     | 0.90     | Fit to geometric mean of theoretical values of Werner <i>et al.</i> (1984) and Rizzo <i>et al.</i> (1988) (see Fig. 3).  |
| <i>a</i> <sup>1</sup> Pi <sub>g</sub> - <i>X</i> <sup>1</sup> Sigma <sub>g</sub> <sup>+</sup>                                | 0.00588  |          |          |          |          |          | <i>R<sub>e</sub></i> =constant from Shemansky (1969b), renormalized to give a <i>v</i> = 0 lifetime of 58 $\mu$ s (Marinelli <i>et al.</i> , 1989). This includes a little contribution from electric quadrupole radiation; see Dahl and Oddershedde (1986). |
| <i>a</i> <sup>1</sup> Pi <sub>g</sub> - <i>a'</i> <sup>1</sup> Sigma <sub>u</sub> <sup>-</sup>                               |          |          |          | 0.346    | 1.15     | 0.60     | Fit to theoretical values of Yeager and McKoy (1977) (see Fig. 4).   |
| <i>w</i> <sup>1</sup> Delta <sub>u</sub> - <i>a</i> <sup>1</sup> Pi <sub>g</sub>   |          |          |          | 0.266    | 1.85     | 0.90     | Fit to theoretical values of Yeager and McKoy (1977) (see Fig. 5).   |
| <i>C</i> <sup>3</sup> Pi <sub>u</sub> - <i>B</i> <sup>3</sup> Pi <sub>g</sub>  |          |          |          | 0.887    | 3.30     | 0.95     | Fit to theoretical values of Werner <i>et al.</i> (1984) (see Fig. 6).   |

Table 1. Coefficients of analytic fits to the electronic transition moments of  $N_2$ ,  $N_2^+$ , and  $O_2^+$  band systems. - Continued

$$R_e(r) = a + br + cr^2 + d \exp[-f(r - g)^2] \quad (R_e \text{ is in electric dipole moment atomic units; } r \text{ is in } \text{\AA}.)$$

| Band system | <i>a</i>                          | <i>b</i> | <i>c</i> | <i>d</i> | <i>f</i> | <i>g</i> | References   |
|-------------|-----------------------------------|----------|----------|----------|----------|----------|--|
| $N_2$       | $E\ 3\Sigma_g^+ - A\ 3\Sigma_u^+$ |          |          | 0.0173   | 106      | 1.25     | Fit to relative $R_e(\bar{r})$ values derived from spectral measurements on the EXCEDE rocket-lofted electron-gun experiment (furnished by W. Reidy, private communication, 1986) (see Fig. 7); $R_e = \text{constant}$ is assumed for the $E-B$ and $E-C$ transitions. Absolute normalization from $E$ -state lifetime of 190 $\mu\text{s}$ (Borst and Zipf, 1971) and relative radiation rates of the three band systems (Freund, 1969). |
|             | $E\ 3\Sigma_g^+ - B\ 3\Pi_g$      | 0.00185  |          |          |          |          |  |
|             | $E\ 3\Sigma_g^+ - C\ 3\Pi_u$      | 0.0414   |          |          |          |          |  |
|             | $D\ 3\Sigma_u^+ - B\ 3\Pi_g$      |          |          | 0.794    | 9.25     | 1.33     | Fit to relative $R_e(\bar{r})$ values derived from emission data of Filippelli <i>et al.</i> (1984) (see Fig. 8); normalized to give a $v = 0$ lifetime of 14.1 ns (Kurzweg <i>et al.</i> , 1973).   |
| $N_2^+$     | $A\ 2\Pi_u - X\ 2\Sigma_g^+$      |          |          | 0.288    | 1.35     | 0.85     | Fit to theoretical values of Langhoff <i>et al.</i> (1987) (see Fig. 9).   |
|             | $B\ 2\Sigma_u^+ - X\ 2\Sigma_g^+$ | 1.051    | 0.2033   | -0.4646  |          |          | Fit to theoretical values of Langhoff and Bauschlicher (1988) (see Fig. 10). Calculation using this fit yields a $v = 0$ lifetime of 62.3 ns, which is within 2% of the measurement of Schmoranzer <i>et al.</i> (1989) (see Table 19).  |
|             | $C\ 2\Sigma_u^+ - X\ 2\Sigma_g^+$ |          |          | 0.315    | 13.5     | 1.45     | Fit to theoretical values of Langhoff and Bauschlicher (1988) (see Fig. 11).   |
| $O_2^+$     | $A\ 2\Pi_u - X\ 2\Pi_g$           | 0.120    |          | 1.72     | 1.26     | 2.83     | Fit to theoretical values of Blomberg and Liu (1988) (see Fig. 12).  |
|             | $b\ 4\Sigma_g^- - a\ 4\Pi_u$      |          |          | 0.290    | 2.43     | 0.96     | Fit to theoretical values of Blomberg and Liu (1988) and Langhoff <i>et al.</i> (1989) (see Fig. 13).  |

Table 2. Radiative transition parameters for  $N_2 A^3\Sigma_u^+ - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ .

| $V' \setminus V''$ | 0         | 1         | 2           | 3           | 4           | 5           | 6           | 7           | 8           | 9           | 10          |
|--------------------|-----------|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 0                  | .2010     | .2109     | .2216       | .2334       | .2463       | .2605       | .2762       | .2937       | .3133       | .3354       | .3604       |
|                    | 49754.8   | 47424.4   | 45122.9     | 42850.0     | 40606.0     | 38390.7     | 36204.2     | 34046.6     | 31917.9     | 29818.2     | 27747.4     |
|                    | 9.74E-04  | 8.13E-03  | 3.21E-02    | 7.98E-02    | 1.40E-01    | 1.85E-01    | 1.91E-01    | 1.57E-01    | 1.06E-01    | 5.85E-02    | 2.70E-02    |
|                    | 1.1850    | 1.2019    | 1.2193      | 1.2372      | 1.2555      | 1.2744      | 1.2939      | 1.3141      | 1.3350      | 1.3566      | 1.3791      |
|                    | -1.26E-06 | -1.54E-05 | -2.99E-05   | -4.48E-05   | -5.98E-05   | -7.53E-05   | -9.12E-05   | -1.07E-04   | -1.24E-04   | -1.41E-04   | -1.59E-04   |
| ( 2.58E-07)        | 2.79E-04  | 3.57E-03  | 1.70E-02    | 4.54E-02    | 8.01E-02    | 1.02E-01    | 9.68E-02    | 7.16E-02    | 4.19E-02    | 1.97E-02    |             |
|                    | 1.97E-07* | 2.75E-04* | 3.54E-03    | 1.69E-02    | 4.53E-02    | 8.01E-02    | 1.02E-01    | 9.69E-02    | 7.17E-02    | 4.20E-02    | 1.98E-02    |
| 1                  | .1954     | .2047     | .2148       | .2258       | .2379       | .2511       | .2657       | .2819       | .2998       | .3200       | .3427       |
|                    | 51187.7   | 48857.3   | 46555.8     | 44282.9     | 42038.9     | 39823.6     | 37637.1     | 35479.5     | 33350.8     | 31251.1     | 29180.3     |
|                    | 5.18E-03  | 3.21E-02  | 8.69E-02    | 1.31E-01    | 1.10E-01    | 4.02E-02    | 2.17E-05    | 3.66E-02    | 1.09E-01    | 1.50E-01    | 1.35E-01    |
|                    | 1.1746    | 1.1911    | 1.2079      | 1.2251      | 1.2426      | 1.2597      | 1.1668      | 1.3034      | 1.3223      | 1.3428      | 1.3643      |
|                    | 7.49E-06  | 6.38E-06  | 2.04E-05    | -3.47E-05   | -4.92E-05   | -6.33E-05   | 1.41E-05    | -9.88E-05   | -1.14E-04   | -1.30E-04   | -1.48E-04   |
|                    | 5.27E-05  | 2.06E-04  | 4.95E-03    | 1.85E-02    | 2.69E-02    | 1.37E-02    | ( 3.10E-07) | 2.16E-02    | 7.13E-02    | 1.05E-01    | 9.87E-02    |
|                    | 5.47E-05* | 1.97E-04  | 4.91E-03    | 1.85E-02    | 2.69E-02    | 1.38E-02    | 3.01E-09*   | 2.14E-02    | 7.12E-02    | 1.05E-01    | 9.87E-02    |
| 2                  | .1901     | .1990     | .2085       | .2189       | .2302       | .2425       | .2561       | .2711       | .2877       | .3062       | .3270       |
|                    | 52592.9   | 50262.6   | 47961.0     | 45688.2     | 43444.1     | 41228.8     | 39042.4     | 36884.8     | 34756.1     | 32656.3     | 30585.6     |
|                    | 1.47E-02  | 6.59E-02  | 1.14E-01    | 8.27E-02    | 1.13E-02    | 1.49E-02    | 7.76E-02    | 8.15E-02    | 2.20E-02    | 3.62E-03    | 6.18E-02    |
|                    | 1.1646    | 1.1806    | 1.1969      | 1.2133      | 1.2275      | 1.2537      | 1.2693      | 1.2871      | 1.3039      | 1.3396      | 1.3518      |
|                    | 1.59E-05  | 2.44E-06  | -1.12E-05   | -2.49E-05   | -3.67E-05   | -5.84E-05   | -7.11E-05   | -8.56E-05   | -9.92E-05   | -1.28E-04   | -1.38E-04   |
|                    | 7.36E-04  | 6.72E-05  | 2.14E-03    | 6.63E-03    | 1.69E-03    | 4.81E-03    | 3.16E-02    | 4.05E-02    | 1.23E-02    | 2.79E-03    | 4.53E-02    |
|                    | 7.45E-04  | 6.97E-05  | 2.14E-03    | 6.66E-03    | 1.73E-03    | 4.73E-03    | 3.15E-02    | 4.06E-02    | 1.24E-02    | 2.73E-03*   | 4.51E-02    |
| 3                  | .1853     | .1936     | .2027       | .2125       | .2231       | .2347       | .2474       | .2614       | .2768       | .2938       | .3129       |
|                    | 53970.4   | 51640.1   | 49338.5     | 47065.7     | 44821.6     | 42606.3     | 40419.9     | 38262.3     | 36133.5     | 34033.8     | 31963.1     |
|                    | 2.99E-02  | 9.32E-02  | 9.01E-02    | 1.50E-02    | 1.53E-02    | 7.20E-02    | 4.55E-02    | 3.10E-05    | 4.24E-02    | 8.11E-02    | 3.68E-02    |
|                    | 1.1551    | 1.1706    | 1.1863      | 1.2003      | 1.2242      | 1.2388      | 1.2550      | 1.1644      | 1.2969      | 1.3145      | 1.3325      |
|                    | 2.40E-05  | 1.09E-05  | -2.36E-06   | -1.41E-05   | -3.40E-05   | -4.61E-05   | -5.94E-05   | 1.61E-05    | -9.36E-05   | -1.08E-04   | -1.22E-04   |
|                    | 3.65E-03  | 2.05E-03  | 8.11E-05    | 4.18E-04    | 2.15E-03    | 1.60E-02    | 1.43E-02    | ( 6.08E-07) | 2.37E-02    | 5.01E-02    | 2.42E-02    |
|                    | 3.70E-03  | 2.06E-03  | 8.19E-05    | 4.40E-04    | 2.10E-03    | 1.60E-02    | 1.44E-02    | 2.86E-09*   | 2.36E-02    | 5.02E-02    | 2.43E-02    |
| 4                  | .1808     | .1887     | .1973       | .2065       | .2166       | .2275       | .2394       | .2524       | .2668       | .2826       | .3002       |
|                    | 55320.1   | 52989.7   | 50688.1     | 48415.3     | 46171.3     | 43956.0     | 41769.5     | 39611.9     | 37483.2     | 35383.4     | 33312.7     |
|                    | 4.85E-02  | 1.00E-01  | 4.16E-02    | 2.89E-03    | 5.90E-02    | 4.13E-02    | 3.61E-04    | 4.89E-02    | 5.34E-02    | 2.41E-03    | 3.05E-02    |
|                    | 1.1459    | 1.1610    | 1.1756      | 1.2012      | 1.2110      | 1.2260      | 1.2755      | 1.2650      | 1.2811      | 1.2876      | 1.3251      |
|                    | 3.18E-05  | 1.90E-05  | 6.65E-06    | -1.48E-05   | -2.30E-05   | -3.55E-05   | -7.62E-05   | -6.76E-05   | -8.08E-05   | -8.60E-05   | -1.16E-04   |
|                    | 1.12E-02  | 7.27E-03  | 3.23E-04    | ( 9.77E-05) | 4.16E-03    | 5.97E-03    | ( 2.06E-04) | 1.88E-02    | 2.48E-02    | 1.07E-03    | 2.06E-02    |
|                    | 1.13E-02  | 7.29E-03  | 3.06E-04    | 8.56E-05*   | 4.11E-03    | 6.03E-03    | 1.87E-04*   | 1.86E-02    | 2.49E-02    | 1.11E-03*   | 2.04E-02    |
| 5                  | .1765     | .1841     | .1923       | .2011       | .2106       | .2209       | .2321       | .2443       | .2577       | .2724       | .2887       |
|                    | 56641.8   | 54311.4   | 52009.8     | 49737.0     | 47492.9     | 45277.7     | 43091.2     | 40933.6     | 38804.9     | 36705.1     | 34634.4     |
|                    | 6.70E-02  | 8.56E-02  | 6.49E-03    | 3.28E-02    | 5.30E-02    | 9.37E-04    | 3.81E-02    | 4.48E-02    | 1.15E-04    | 4.08E-02    | 5.10E-02    |
|                    | 1.1371    | 1.1517    | 1.1632      | 1.1854      | 1.1996      | 1.2003      | 1.2362      | 1.2510      | 1.2095      | 1.2914      | 1.3076      |
|                    | 3.93E-05  | 2.69E-05  | 1.71E-05    | -1.60E-06   | -1.35E-05   | -1.41E-05   | -4.39E-05   | -5.61E-05   | -2.18E-05   | -8.91E-05   | -1.02E-04   |
|                    | 2.54E-02  | 1.34E-02  | 3.62E-04    | ( 1.39E-05) | 1.40E-03    | ( 2.33E-05) | 7.95E-03    | 1.31E-02    | ( 4.31E-06) | 2.16E-02    | 2.99E-02    |
|                    | 2.55E-02  | 1.34E-02  | 3.39E-04*   | 1.05E-05    | 1.41E-03    | 3.08E-05*   | 7.86E-03    | 1.31E-02    | 7.97E-06*   | 2.15E-02    | 3.00E-02    |
| 6                  | .1726     | .1798     | .1876       | .1960       | .2050       | .2147       | .2253       | .2368       | .2494       | .2632       | .2783       |
|                    | 57935.3   | 55605.0   | 53303.4     | 51030.5     | 48786.5     | 46571.2     | 44384.8     | 42227.1     | 40098.4     | 37998.7     | 35928.0     |
|                    | 8.19E-02  | 5.81E-02  | 1.55E-03    | 5.49E-02    | 1.62E-02    | 1.69E-02    | 4.82E-02    | 1.91E-03    | 3.32E-02    | 4.04E-02    | 2.23E-06    |
|                    | 1.1286    | 1.1426    | 1.1681      | 1.1749      | 1.1876      | 1.2105      | 1.2236      | 1.2280      | 1.2615      | 1.2761      | 1.7893      |
|                    | 4.66E-05  | 3.46E-05  | 1.30E-05    | 7.24E-06    | -3.45E-06   | -2.26E-05   | -3.35E-05   | -3.72E-05   | -6.48E-05   | -7.67E-05   | -4.58E-04   |
|                    | 4.67E-02  | 1.62E-02  | ( 5.36E-05) | 5.17E-04    | ( 3.02E-05) | 1.17E-03    | 6.39E-03    | 2.68E-04    | 1.21E-02    | 1.76E-02    | ( 2.94E-05) |
|                    | 4.68E-02  | 1.61E-02  | 6.35E-05*   | 5.24E-04    | 3.79E-05    | 1.13E-03    | 6.42E-03    | 2.92E-04*   | 1.20E-02    | 1.77E-02    | 2.63E-05*   |
| 7                  | .1689     | .1758     | .1833       | .1912       | .1998       | .2090       | .2191       | .2299       | .2418       | .2547       | .2689       |
|                    | 59200.5   | 56870.2   | 54568.6     | 52295.8     | 50051.7     | 47836.4     | 45650.0     | 43492.4     | 41363.6     | 39263.9     | 37193.2     |
|                    | 9.11E-02  | 2.97E-02  | 1.82E-02    | 4.74E-02    | 2.93E-05    | 4.33E-02    | 1.44E-02    | 1.62E-02    | 4.21E-02    | 4.27E-04    | 3.65E-02    |
|                    | 1.1205    | 1.1336    | 1.1525      | 1.1651      | 1.2652      | 1.1984      | 1.2106      | 1.2350      | 1.2478      | 1.2341      | 1.2868      |
|                    | 5.35E-05  | 4.23E-05  | 2.62E-05    | 1.55E-05    | -6.78E-05   | -1.25E-05   | -2.27E-05   | -4.29E-05   | -5.35E-05   | -4.22E-05   | -8.54E-05   |
|                    | 7.31E-02  | 1.32E-02  | 2.74E-03    | 2.21E-03    | ( 2.28E-05) | 1.00E-03    | 9.50E-04    | 3.32E-03    | 1.15E-02    | ( 6.22E-05) | 1.85E-02    |
|                    | 7.33E-02  | 1.31E-02  | 2.81E-03    | 2.19E-03    | 1.68E-05*   | 9.83E-04    | 9.87E-04    | 3.25E-03    | 1.16E-02    | 7.46E-05*   | 1.84E-02    |

Table 2. Radiative transition parameters for  $N_2 A^3\Sigma_u^+ - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \setminus v''$ | 11        | 12          | 13        | 14        | 15        | 16        | 17        | 18        | 19        | 20        | 21       |
|--------------------|-----------|-------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|
| 0                  | .3890     | .4221       | .4606     | .5062     | .5608     | .6274     | .7106     | .8171     | .9584     | 1.1548    | 1.4460   |
|                    | 25705.8   | 23693.4     | 21710.3   | 19756.6   | 17832.4   | 15937.9   | 14073.2   | 12238.4   | 10433.8   | 8659.5    | 6915.7   |
| 1.04E-02           | 3.35E-03  | 9.06E-04    | 2.06E-04  | 3.90E-05  | 6.17E-06  | 8.06E-07  | 8.62E-08  | 7.47E-09  | 5.17E-10  | 2.71E-11  |          |
| 1.4025             | 1.4270    | 1.4527      | 1.4797    | 1.5083    | 1.5386    | 1.5711    | 1.6062    | 1.6440    | 1.6849    | 1.7367    |          |
| -1.78E-04          | -1.97E-04 | -2.16E-04   | -2.37E-04 | -2.58E-04 | -2.81E-04 | -3.05E-04 | -3.31E-04 | -3.58E-04 | -3.87E-04 | -4.23E-04 |          |
| 7.50E-03           | 2.32E-03  | 5.86E-04    | 1.20E-04  | 2.00E-05  | 2.67E-06  | 2.82E-07  | 2.33E-08  | 1.47E-09  | 6.78E-11  | 2.16E-12  |          |
| 7.52E-03           | 2.33E-03* | 5.88E-04*   | 1.21E-04* | 2.01E-05* | 2.68E-06* | 2.84E-07* | 2.34E-08* | 1.48E-09* | 6.82E-11* | 2.18E-12* |          |
| 1                  | .3685     | .3980       | .4321     | .4719     | .5191     | .5757     | .6449     | .7315     | .8427     | .9908     | 1.1978   |
|                    | 27138.7   | 25126.3     | 23143.2   | 21189.5   | 19265.3   | 17370.8   | 15506.1   | 13671.3   | 11866.7   | 10092.4   | 8348.6   |
| 8.97E-02           | 4.62E-02  | 1.90E-02    | 6.30E-03  | 1.71E-03  | 3.80E-04  | 6.91E-05  | 1.02E-05  | 1.23E-06  | 1.18E-07  | 8.99E-09  |          |
| 1.3867             | 1.4101    | 1.4346      | 1.4603    | 1.4874    | 1.5160    | 1.5465    | 1.5791    | 1.6143    | 1.6526    | 1.6940    |          |
| -1.65E-04          | -1.83E-04 | -2.02E-04   | -2.22E-04 | -2.43E-04 | -2.64E-04 | -2.87E-04 | -3.11E-04 | -3.37E-04 | -3.64E-04 | -3.93E-04 |          |
| 6.60E-02           | 3.33E-02  | 1.30E-02    | 4.00E-03  | 9.73E-04  | 1.88E-04  | 2.87E-05  | 3.42E-06  | 3.14E-07  | 2.17E-08  | 1.09E-09  |          |
| 6.61E-02           | 3.33E-02  | 1.30E-02    | 4.01E-03* | 9.76E-04* | 1.89E-04* | 2.88E-05* | 3.43E-06* | 3.16E-07* | 2.18E-08* | 1.10E-09* |          |
| 2                  | .3503     | .3769       | .4074     | .4426     | .4838     | .5326     | .5913     | .6633     | .7535     | .8697     | 1.0252   |
|                    | 28544.0   | 26531.5     | 24548.4   | 22594.7   | 20670.5   | 18776.0   | 16911.3   | 15076.6   | 13272.0   | 11497.6   | 9753.8   |
| 1.27E-01           | 1.37E-01  | 1.00E-01    | 5.38E-02  | 2.23E-02  | 7.30E-03  | 1.91E-03  | 4.01E-04  | 6.76E-05  | 9.11E-06  | 9.71E-07  |          |
| 1.3724             | 1.3946    | 1.4179      | 1.4423    | 1.4681    | 1.4952    | 1.5239    | 1.5545    | 1.5872    | 1.6225    | 1.6610    |          |
| -1.54E-04          | -1.71E-04 | -1.89E-04   | -2.08E-04 | -2.28E-04 | -2.49E-04 | -2.70E-04 | -2.93E-04 | -3.17E-04 | -3.42E-04 | -3.70E-04 |          |
| 9.45E-02           | 1.02E-01  | 7.18E-02    | 3.64E-02  | 1.38E-02  | 4.04E-03  | 9.10E-04  | 1.59E-04  | 2.14E-05  | 2.19E-06  | 1.67E-07  |          |
| 9.43E-02           | 1.02E-01  | 7.18E-02    | 3.64E-02  | 1.39E-02  | 4.05E-03* | 9.13E-04* | 1.60E-04* | 2.15E-05* | 2.20E-06* | 1.67E-07* |          |
| 3                  | .3342     | .3583       | .3857     | .4171     | .4536     | .4962     | .5468     | .6078     | .6826     | .7767     | .8984    |
|                    | 29921.5   | 27909.0     | 25925.9   | 23972.2   | 22048.0   | 20153.5   | 18288.8   | 16454.1   | 14649.4   | 12875.1   | 11131.3  |
| 9.23E-05           | 4.58E-02  | 1.16E-01    | 1.35E-01  | 9.96E-02  | 5.28E-02  | 2.11E-02  | 6.56E-03  | 1.60E-03  | 3.07E-04  | 4.65E-05  |          |
| 1.4392             | 1.3821    | 1.4030      | 1.4260    | 1.4503    | 1.4760    | 1.5032    | 1.5319    | 1.5626    | 1.5954    | 1.6310    |          |
| -2.06E-04          | -1.62E-04 | -1.78E-04   | -1.96E-04 | -2.14E-04 | -2.34E-04 | -2.55E-04 | -2.76E-04 | -2.99E-04 | -3.23E-04 | -3.49E-04 |          |
| 1.42E-04           | 3.51E-02  | 8.66E-02    | 9.60E-02  | 6.63E-02  | 3.20E-02  | 1.13E-02  | 3.01E-03  | 6.05E-04  | 9.22E-05  | 1.05E-05  |          |
| 1.30E-04*          | 3.49E-02  | 8.64E-02    | 9.59E-02  | 6.64E-02  | 3.21E-02  | 1.14E-02  | 3.02E-03* | 6.07E-04* | 9.26E-05* | 1.06E-05* |          |
| 4                  | .3198     | .3418       | .3666     | .3949     | .4274     | .4650     | .5092     | .5617     | .6250     | .7030     | .8012    |
|                    | 31271.1   | 29258.7     | 27275.6   | 25321.9   | 23397.7   | 21503.2   | 19638.5   | 17803.7   | 15999.1   | 14224.8   | 12481.0  |
| 7.61E-02           | 3.80E-02  | 5.32E-05    | 4.65E-02  | 1.17E-01  | 1.31E-01  | 9.26E-02  | 4.63E-02  | 1.72E-02  | 4.89E-03  | 1.08E-03  |          |
| 1.3425             | 1.3608    | 1.5097      | 1.4129    | 1.4346    | 1.4586    | 1.4842    | 1.5113    | 1.5402    | 1.5709    | 1.6039    |          |
| -1.30E-04          | -1.45E-04 | -2.60E-04   | -1.86E-04 | -2.02E-04 | -2.21E-04 | -2.40E-04 | -2.61E-04 | -2.82E-04 | -3.05E-04 | -3.29E-04 |          |
| 5.33E-02           | 2.69E-02  | 9.83E-05    | 3.51E-02  | 8.29E-02  | 8.59E-02  | 5.47E-02  | 2.40E-02  | 7.58E-03  | 1.77E-03  | 3.06E-04  |          |
| 5.33E-02           | 2.70E-02  | 8.94E-05*   | 3.50E-02  | 8.27E-02  | 8.59E-02  | 5.48E-02  | 2.40E-02  | 7.60E-03  | 1.77E-03* | 3.07E-04* |          |
| 5                  | .3068     | .3270       | .3497     | .3753     | .4045     | .4381     | .4771     | .5229     | .5773     | .6432     | .7245    |
|                    | 32592.8   | 30580.4     | 28597.3   | 26643.5   | 24719.4   | 22824.8   | 20960.1   | 19125.4   | 17320.8   | 15546.5   | 13802.6  |
| 2.16E-03           | 3.15E-02  | 7.33E-02    | 3.06E-02  | 1.36E-03  | 5.83E-02  | 1.24E-01  | 1.25E-01  | 8.05E-02  | 3.65E-02  | 1.22E-02  |          |
| 1.3121             | 1.3533    | 1.3711      | 1.3894    | 1.4444    | 1.4444    | 1.4673    | 1.4927    | 1.5197    | 1.5486    | 1.5794    |          |
| -1.06E-04          | -1.39E-04 | -1.53E-04   | -1.67E-04 | -2.10E-04 | -2.10E-04 | -2.27E-04 | -2.47E-04 | -2.67E-04 | -2.89E-04 | -3.11E-04 |          |
| 1.13E-03           | 2.34E-02  | 5.41E-02    | 2.19E-02  | 1.23E-03  | 4.12E-02  | 7.98E-02  | 7.21E-02  | 4.03E-02  | 1.54E-02  | 4.20E-03  |          |
| 1.18E-03*          | 2.33E-02  | 5.41E-02    | 2.20E-02  | 1.19E-03* | 4.11E-02  | 7.97E-02  | 7.21E-02  | 4.04E-02  | 1.55E-02  | 4.22E-03  |          |
| 6                  | .2951     | .3137       | .3346     | .3579     | .3844     | .4146     | .4494     | .4897     | .5372     | .5938     | .6624    |
|                    | 33886.3   | 31873.9     | 29890.8   | 27937.1   | 26012.9   | 24118.4   | 22253.7   | 20419.0   | 18614.3   | 16840.0   | 15096.2  |
| 4.25E-02           | 4.38E-02  | 1.98E-04    | 4.06E-02  | 6.93E-02  | 1.81E-02  | 8.03E-03  | 7.85E-02  | 1.31E-01  | 1.14E-01  | 6.47E-02  |          |
| 1.3180             | 1.3343    | 1.2937      | 1.3817    | 1.4003    | 1.4175    | 1.4612    | 1.4770    | 1.5015    | 1.5284    | 1.5572    |          |
| -1.11E-04          | -1.24E-04 | -9.10E-05   | -1.61E-04 | -1.76E-04 | -1.89E-04 | -2.23E-04 | -2.35E-04 | -2.53E-04 | -2.74E-04 | -2.95E-04 |          |
| 2.73E-02           | 2.93E-02  | ( 5.91E-05) | 3.11E-02  | 5.09E-02  | 1.23E-02  | 5.93E-03  | 4.98E-02  | 7.35E-02  | 5.52E-02  | 5.61E-02  | 2.61E-02 |
| 2.72E-02           | 2.94E-02  | 6.97E-05*   | 3.09E-02  | 5.09E-02  | 1.24E-02  | 5.86E-03* | 4.96E-02  | 7.35E-02  | 5.53E-02  | 5.62E-02  | 2.62E-02 |
| 7                  | .2845     | .3018       | .3210     | .3424     | .3666     | .3940     | .4252     | .4612     | .5030     | .5523     | .6112    |
|                    | 35151.6   | 33139.1     | 31156.0   | 29202.3   | 27278.1   | 25383.6   | 23518.9   | 21684.2   | 19879.5   | 18105.2   | 16361.4  |
| 3.15E-02           | 1.64E-03  | 4.87E-02    | 3.17E-02  | 1.64E-03  | 5.44E-02  | 5.91E-02  | 5.24E-03  | 2.49E-02  | 1.03E-01  | 1.33E-01  |          |
| 1.3014             | 1.3434    | 1.3449      | 1.3611    | 1.4105    | 1.4107    | 1.4301    | 1.4406    | 1.4896    | 1.5111    | 1.5375    |          |
| -9.72E-05          | -1.31E-04 | -1.32E-04   | -1.45E-04 | -1.84E-04 | -1.84E-04 | -1.99E-04 | -2.07E-04 | -2.44E-04 | -2.61E-04 | -2.80E-04 |          |
| 1.75E-02           | 1.38E-03  | 3.47E-02    | 2.24E-02  | 1.52E-03  | 4.06E-02  | 4.11E-02  | 3.09E-03  | 1.58E-02  | 5.62E-02  | 6.20E-02  |          |
| 1.76E-02           | 1.33E-03* | 3.47E-02    | 2.25E-02  | 1.48E-03* | 4.05E-02  | 4.12E-02  | 3.14E-03* | 1.57E-02  | 5.61E-02  | 6.20E-02  |          |

Table 2. Radiative transition parameters for  $N_2 A^3\Sigma_u^+ - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 0         | 1         | 2           | 3           | 4           | 5           | 6           | 7           | 8           | 9           | 10      |
|---------------------|-----------|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------|
| 8                   | .1655     | .1721     | .1792       | .1868       | .1950       | .2038       | .2133       | .2236       | .2347       | .2469       | .2602   |
|                     | 60437.1   | 58106.8   | 55805.2     | 53532.4     | 51288.3     | 49073.0     | 46886.6     | 44729.0     | 42600.3     | 40500.5     | 38429.8 |
| 9.39E-02            | 9.34E-03  | 3.82E-02  | 2.33E-02    | 1.39E-02    | 3.76E-02    | 5.31E-04    | 4.05E-02    | 7.66E-03    | 2.22E-02    | 3.36E-02    |         |
| 1.1126              | 1.1241    | 1.1430    | 1.1552      | 1.1758      | 1.1877      | 1.2274      | 1.2219      | 1.2322      | 1.2590      | 1.2721      |         |
| 6.03E-05            | 5.04E-05  | 3.43E-05  | 2.39E-05    | 6.48E-06    | -3.53E-06   | -3.67E-05   | -3.21E-05   | -4.06E-05   | -6.27E-05   | -7.34E-05   |         |
| 1.02E-01            | 6.30E-03  | 1.05E-02  | 2.76E-03    | ( 1.07E-04) | 7.49E-05    | ( 9.93E-05) | 5.04E-03    | 1.32E-03    | 7.84E-03    | 1.39E-02    |         |
| 1.02E-01            | 6.21E-03* | 1.06E-02  | 2.70E-03    | 1.20E-04    | 8.00E-05    | 8.49E-05*   | 5.02E-03    | 1.37E-03    | 7.75E-03    | 1.40E-02    |         |
| 9                   | .1622     | .1686     | .1754       | .1827       | .1905       | .1989       | .2079       | .2177       | .2283       | .2398       | .2523   |
|                     | 61644.8   | 59314.4   | 57012.9     | 54740.0     | 52496.0     | 50280.7     | 48094.3     | 45936.6     | 43807.9     | 41708.2     | 39637.5 |
| 9.10E-02            | 5.11E-04  | 4.84E-02  | 4.15E-03    | 3.37E-02    | 1.32E-02    | 1.88E-02    | 2.71E-02    | 4.21E-03    | 3.79E-02    | 1.25E-03    |         |
| 1.1051              | 1.1059    | 1.1344    | 1.1430      | 1.1653      | 1.1765      | 1.1984      | 1.2103      | 1.2374      | 1.2456      | 1.2443      |         |
| 6.68E-05            | 6.61E-05  | 4.16E-05  | 3.43E-05    | 1.54E-05    | 5.89E-06    | -1.25E-05   | -2.24E-05   | -4.49E-05   | -5.17E-05   | -5.06E-05   |         |
| 1.28E-01            | 6.29E-04  | 2.10E-02  | 1.08E-03    | 1.55E-03    | ( 7.89E-05) | 4.41E-04    | 1.79E-03    | 9.65E-04    | 9.93E-03    | 2.68E-04    |         |
| 1.28E-01            | 5.96E-04* | 2.10E-02  | 1.03E-03*   | 1.58E-03    | 6.76E-05    | 4.20E-04    | 1.83E-03    | 9.22E-04*   | 9.93E-03    | 2.93E-04*   |         |
| 10                  | .1592     | .1653     | .1718       | .1788       | .1863       | .1943       | .2030       | .2122       | .2223       | .2352       | .2450   |
|                     | 62823.2   | 60492.8   | 58191.2     | 55918.4     | 53674.3     | 51459.1     | 49272.6     | 47115.0     | 44986.3     | 42886.5     | 40815.8 |
| 8.40E-02            | 1.93E-03  | 4.56E-02  | 5.96E-04    | 3.88E-02    | 1.31E-04    | 3.47E-02    | 3.75E-03    | 2.69E-02    | 1.43E-02    | 1.35E-02    |         |
| 1.0979              | 1.1189    | 1.1263    | 1.1577      | 1.1561      | 1.1315      | 1.1876      | 1.1950      | 1.2212      | 1.2322      | 1.2578      |         |
| 7.30E-05            | 5.49E-05  | 4.86E-05  | 2.18E-05    | 2.31E-05    | 4.41E-05    | -3.45E-06   | -9.65E-06   | -3.15E-05   | -4.06E-05   | -6.17E-05   |         |
| 1.50E-01            | 1.74E-03  | 2.86E-02  | ( 6.68E-05) | 4.34E-03    | ( 4.69E-05) | 6.66E-05    | ( 4.93E-05) | 3.29E-03    | 2.52E-03    | 4.73E-03    |         |
| 1.50E-01            | 1.80E-03* | 2.85E-02  | 7.96E-05*   | 4.34E-03    | 3.62E-05*   | 6.39E-05    | 6.06E-05*   | 3.24E-03    | 2.58E-03    | 4.65E-03    |         |
| 11                  | .1563     | .1622     | .1685       | .1752       | .1824       | .1901       | .1983       | .2072       | .2168       | .2271       | .2383   |
|                     | 63971.7   | 61641.4   | 59339.8     | 57066.9     | 54822.9     | 52607.6     | 50421.2     | 48263.5     | 46134.8     | 44035.1     | 41964.4 |
| 7.44E-02            | 9.94E-03  | 3.38E-02  | 9.69E-03    | 2.79E-02    | 6.79E-03    | 2.86E-02    | 2.78E-03    | 3.14E-02    | 5.46E-05    | 3.23E-02    |         |
| 1.0910              | 1.1078    | 1.1185    | 1.1373      | 1.1472      | 1.1684      | 1.1777      | 1.2037      | 1.2101      | 1.3074      | 1.2442      |         |
| 7.90E-05            | 6.45E-05  | 5.52E-05  | 3.91E-05    | 3.07E-05    | 1.27E-05    | 4.88E-06    | -1.69E-05   | -2.23E-05   | -1.02E-04   | -5.05E-05   |         |
| 1.64E-01            | 1.31E-02  | 2.91E-02  | 3.73E-03    | 5.85E-03    | 2.16E-04    | 1.18E-04    | ( 1.21E-04) | 2.07E-03    | ( 6.56E-05) | 8.23E-03    |         |
| 1.64E-01            | 1.32E-02* | 2.90E-02  | 3.80E-03*   | 5.80E-03    | 2.39E-04*   | 1.11E-04    | 1.05E-04*   | 2.07E-03    | 5.45E-05*   | 8.20E-03    |         |
| 12                  | .1536     | .1593     | .1654       | .1719       | .1788       | .1861       | .1940       | .2025       | .2116       | .2215       | .2321   |
|                     | 65089.9   | 62759.5   | 60458.0     | 58185.1     | 55941.1     | 53725.8     | 51539.3     | 49381.7     | 47253.0     | 45153.3     | 43082.6 |
| 6.38E-02            | 2.05E-02  | 1.95E-02  | 2.24E-02    | 1.21E-02    | 2.12E-02    | 1.13E-02    | 1.82E-02    | 1.42E-02    | 1.33E-02    | 2.02E-02    |         |
| 1.0844              | 1.1000    | 1.1108    | 1.1284      | 1.1379      | 1.1576      | 1.1673      | 1.1886      | 1.1989      | 1.2219      | 1.2322      |         |
| 8.47E-05            | 7.12E-05  | 6.19E-05  | 4.68E-05    | 3.86E-05    | 2.19E-05    | 1.37E-05    | -4.29E-06   | -1.29E-05   | -3.21E-05   | -4.06E-05   |         |
| 1.71E-01            | 3.47E-02  | 2.23E-02  | 1.31E-02    | 4.25E-03    | 2.13E-03    | 3.91E-04    | ( 5.45E-05) | 3.38E-04    | 1.70E-03    | 3.60E-03    |         |
| 1.70E-01            | 3.49E-02  | 2.21E-02  | 1.32E-02    | 4.17E-03    | 2.17E-03    | 3.64E-04    | 4.66E-05    | 3.59E-04    | 1.65E-03    | 3.65E-03    |         |
| 13                  | .1511     | .1566     | .1625       | .1687       | .1754       | .1824       | .1900       | .1981       | .2069       | .2163       | .2264   |
|                     | 66177.1   | 63846.7   | 61545.1     | 59272.3     | 57028.2     | 54813.0     | 52626.5     | 50468.9     | 48340.2     | 46240.4     | 44169.7 |
| 5.32E-02            | 3.05E-02  | 7.87E-03  | 3.12E-02    | 1.72E-03    | 2.95E-02    | 6.09E-04    | 2.81E-02    | 7.24E-04    | 2.69E-02    | 1.99E-03    |         |
| 1.0780              | 1.0929    | 1.1029    | 1.1207      | 1.1241      | 1.1490      | 1.1446      | 1.1788      | 1.1756      | 1.2105      | 1.2133      |         |
| 9.03E-05            | 7.73E-05  | 6.87E-05  | 5.34E-05    | 5.04E-05    | 2.92E-05    | 3.29E-05    | 3.95E-06    | 6.65E-06    | -2.26E-05   | -2.49E-05   |         |
| 1.70E-01            | 6.41E-02  | 1.17E-02  | 2.50E-02    | 1.10E-03    | 5.59E-03    | ( 1.30E-04) | 7.62E-05    | ( 4.88E-06) | 1.83E-03    | ( 1.44E-04) |         |
| 1.70E-01            | 6.43E-02  | 1.16E-02* | 2.51E-02    | 1.05E-03*   | 5.63E-03    | 1.12E-04*   | 7.87E-05    | 1.99E-06*   | 1.81E-03    | 1.64E-04*   |         |
| 14                  | .1487     | .1541     | .1597       | .1658       | .1722       | .1790       | .1863       | .1941       | .2024       | .2114       | .2211   |
|                     | 67232.4   | 64902.1   | 62600.5     | 60327.7     | 58083.6     | 55868.4     | 53681.9     | 51524.3     | 49395.6     | 47295.8     | 45225.1 |
| 4.35E-02            | 3.81E-02  | 1.35E-03  | 3.29E-02    | 6.16E-04    | 2.69E-02    | 2.79E-03    | 2.33E-02    | 3.91E-03    | 2.23E-02    | 3.46E-03    |         |
| 1.0720              | 1.0864    | 1.0924    | 1.1135      | 1.1442      | 1.1409      | 1.1644      | 1.1697      | 1.1933      | 1.2004      | 1.2264      |         |
| 9.55E-05            | 8.30E-05  | 7.78E-05  | 5.95E-05    | 3.33E-05    | 3.61E-05    | 1.61E-05    | 1.16E-05    | -8.23E-06   | -1.42E-05   | -3.58E-05   |         |
| 1.63E-01            | 9.68E-02  | 2.71E-03  | 3.46E-02    | ( 1.80E-04) | 8.24E-03    | ( 1.51E-04) | 5.82E-04    | ( 4.31E-05) | 6.40E-04    | 5.54E-04    |         |
| 1.63E-01            | 9.70E-02  | 2.64E-03* | 3.45E-02    | 2.01E-04*   | 8.20E-03    | 1.70E-04*   | 5.65E-04    | 3.39E-05*   | 6.56E-04    | 5.20E-04*   |         |
| 15                  | .1465     | .1517     | .1572       | .1630       | .1692       | .1758       | .1828       | .1903       | .1983       | .2070       | .2162   |
|                     | 68255.1   | 65924.8   | 63623.2     | 61350.4     | 59106.3     | 56891.1     | 54704.6     | 52547.0     | 50418.3     | 48318.5     | 46247.8 |
| 3.49E-02            | 4.26E-02  | 1.40E-04  | 2.83E-02    | 6.45E-03    | 1.72E-02    | 1.23E-02    | 1.09E-02    | 1.55E-02    | 8.17E-03    | 1.67E-02    |         |
| 1.0661              | 1.0802    | 1.1136    | 1.1068      | 1.1256      | 1.1330      | 1.1523      | 1.1603      | 1.1810      | 1.1895      | 1.2120      |         |
| 1.01E-04            | 8.84E-05  | 5.95E-05  | 6.53E-05    | 4.92E-05    | 4.28E-05    | 2.64E-05    | 1.96E-05    | 2.10E-06    | -5.04E-06   | -2.39E-05   |         |
| 1.52E-01            | 1.29E-01  | 1.72E-04  | 3.77E-02    | 4.35E-03    | 7.83E-03    | 1.90E-03    | 8.22E-04    | ( 1.19E-05) | ( 3.16E-05) | 1.27E-03    |         |
| 1.52E-01            | 1.29E-01  | 1.91E-04* | 3.76E-02    | 4.44E-03*   | 7.76E-03    | 1.95E-03    | 7.88E-04    | 1.53E-05    | 3.99E-05*   | 1.23E-03    |         |

Table 2. Radiative transition parameters for  $N_2 A^3\Sigma_u^+ - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . – Continued

| $V' \setminus V''$ | 11        | 12        | 13        | 14          | 15        | 16        | 17        | 18        | 19        | 20          | 21        |
|--------------------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|-----------|-----------|-------------|-----------|
| 8                  | .2748     | .2909     | .3087     | .3285       | .3507     | .3757     | .4040     | .4363     | .4736     | .5170       | .5682     |
|                    | 36388.2   | 34375.7   | 32392.6   | 30438.9     | 28514.7   | 26620.2   | 24755.5   | 22920.8   | 21116.2   | 19341.8     | 17598.0   |
|                    | 6.54E-04  | 4.24E-02  | 1.87E-02  | 9.29E-03    | 5.30E-02  | 1.58E-02  | 1.20E-02  | 6.64E-02  | 4.01E-02  | 1.09E-04    | 5.40E-02  |
|                    | 1.3213    | 1.3124    | 1.3262    | 1.3598      | 1.3723    | 1.3869    | 1.4256    | 1.4407    | 1.4602    | 1.6217      | 1.5221    |
|                    | -1.13E-04 | -1.06E-04 | -1.17E-04 | -1.44E-04   | -1.54E-04 | -1.65E-04 | -1.95E-04 | -2.07E-04 | -2.22E-04 | -3.42E-04   | -2.69E-04 |
|                    | 5.46E-04  | 2.62E-02  | 1.18E-02  | 7.33E-03    | 3.93E-02  | 1.10E-02  | 9.39E-03  | 4.63E-02  | 2.51E-02  | 1.25E-04    | 2.87E-02  |
|                    | 5.15E-04* | 2.61E-02  | 1.19E-02  | 7.22E-03*   | 3.93E-02  | 1.11E-02  | 9.29E-03  | 4.63E-02  | 2.52E-02  | 1.17E-04*   | 2.86E-02  |
| 9                  | .2660     | .2810     | .2976     | .3160       | .3364     | .3594     | .3852     | .4144     | .4480     | .4866       | .5318     |
|                    | 37595.8   | 35583.4   | 33600.3   | 31646.6     | 29722.4   | 27827.9   | 25963.2   | 24128.4   | 22323.8   | 20549.5     | 18805.7   |
|                    | 3.14E-02  | 2.08E-02  | 7.40E-03  | 4.42E-02    | 5.47E-03  | 2.47E-02  | 4.83E-02  | 2.42E-03  | 3.28E-02  | 6.75E-02    | 1.65E-02  |
|                    | 1.2832    | 1.2961    | 1.3276    | 1.3384      | 1.3469    | 1.3845    | 1.4002    | 1.4014    | 1.4527    | 1.4716      | 1.4883    |
|                    | -8.25E-05 | -9.29E-05 | -1.18E-04 | -1.27E-04   | -1.34E-04 | -1.63E-04 | -1.76E-04 | -1.77E-04 | -2.16E-04 | -2.31E-04   | -2.43E-04 |
|                    | 1.53E-02  | 1.09E-02  | 5.30E-03  | 3.05E-02    | 3.47E-03  | 1.92E-02  | 3.52E-02  | 1.43E-03  | 2.30E-02  | 4.22E-02    | 8.76E-03  |
|                    | 1.53E-02  | 1.11E-02  | 5.21E-03* | 3.05E-02    | 3.54E-03* | 1.91E-02  | 3.53E-02  | 1.48E-03* | 2.29E-02  | 4.22E-02    | 8.83E-03  |
| 10                 | .2579     | .2720     | .2875     | .3046       | .3236     | .3448     | .3684     | .3952     | .4255     | .4602       | .5004     |
|                    | 38774.2   | 36761.8   | 34778.6   | 32824.9     | 30900.8   | 29006.2   | 27141.5   | 25306.8   | 23502.2   | 21727.9     | 19984.0   |
|                    | 3.00E-02  | 1.06E-03  | 3.79E-02  | 6.76E-03    | 2.18E-02  | 3.59E-02  | 8.18E-05  | 4.26E-02  | 3.13E-02  | 2.10E-03    | 5.66E-02  |
|                    | 1.2692    | 1.3116    | 1.3080    | 1.3172      | 1.3506    | 1.3645    | 1.5028    | 1.4117    | 1.4280    | 1.4834      | 1.4828    |
|                    | -7.11E-05 | -1.05E-04 | -1.03E-04 | -1.10E-04   | -1.37E-04 | -1.48E-04 | -2.54E-04 | -1.85E-04 | -1.97E-04 | -2.40E-04   | -2.39E-04 |
|                    | 1.19E-02  | 7.91E-04  | 2.26E-02  | 3.90E-03    | 1.62E-02  | 2.58E-02  | 1.43E-04  | 3.18E-02  | 2.13E-02  | 1.67E-03    | 3.49E-02  |
|                    | 1.20E-02  | 7.52E-04* | 2.26E-02  | 3.98E-03*   | 1.61E-02  | 2.59E-02  | 1.30E-04* | 3.17E-02  | 2.14E-02  | 1.63E-03*   | 3.48E-02  |
| 11                 | .2505     | .2638     | .2783     | .2943       | .3120     | .3316     | .3535     | .3780     | .4057     | .4371       | .4732     |
|                    | 39922.7   | 37910.3   | 35927.2   | 33973.5     | 32049.3   | 30154.8   | 28290.1   | 26455.4   | 24650.7   | 22876.4     | 21132.6   |
|                    | 2.92E-03  | 2.60E-02  | 1.56E-02  | 1.11E-02    | 3.41E-02  | 1.11E-06  | 3.72E-02  | 1.78E-02  | 1.02E-02  | 5.06E-02    | 9.39E-03  |
|                    | 1.2487    | 1.2807    | 1.2920    | 1.3217      | 1.3330    | 2.2446    | 1.3763    | 1.3896    | 1.4278    | 1.4403      | 1.4519    |
|                    | -5.42E-05 | -8.04E-05 | -8.96E-05 | -1.14E-04   | -1.23E-04 | -7.36E-04 | -1.57E-04 | -1.67E-04 | -1.97E-04 | -2.07E-04   | -2.16E-04 |
|                    | 7.40E-04  | 1.24E-02  | 7.86E-03  | 7.55E-03    | 2.28E-02  | 2.22E-05  | 2.80E-02  | 1.25E-02  | 7.98E-03  | 3.50E-02    | 5.57E-03  |
|                    | 7.81E-04* | 1.23E-02  | 7.96E-03  | 7.45E-03    | 2.29E-02  | 2.27E-05* | 2.79E-02  | 1.26E-02  | 7.89E-03  | 3.50E-02    | 5.63E-03* |
| 12                 | .2437     | .2562     | .2699     | .2850       | .3015     | .3198     | .3400     | .3627     | .3881     | .4168       | .4494     |
|                    | 41040.9   | 39028.5   | 37045.4   | 35091.7     | 33167.5   | 31273.0   | 29408.3   | 27573.5   | 25768.9   | 23994.6     | 22250.8   |
|                    | 6.60E-03  | 2.80E-02  | 7.44E-04  | 3.29E-02    | 2.38E-03  | 2.69E-02  | 1.86E-02  | 8.48E-03  | 4.06E-02  | 1.90E-03    | 3.24E-02  |
|                    | 1.2587    | 1.2673    | 1.3134    | 1.3047      | 1.3066    | 1.3452    | 1.3573    | 1.3927    | 1.4032    | 1.3997      | 1.4529    |
|                    | -6.25E-05 | -6.95E-05 | -1.07E-04 | -9.99E-05   | -1.01E-04 | -1.32E-04 | -1.42E-04 | -1.70E-04 | -1.78E-04 | -1.75E-04   | -2.16E-04 |
|                    | 2.40E-03  | 1.08E-02  | 5.83E-04  | 1.91E-02    | 1.20E-03  | 1.95E-02  | 1.29E-02  | 6.93E-03  | 2.98E-02  | 1.09E-03    | 2.26E-02  |
|                    | 2.34E-03* | 1.09E-02  | 5.50E-04* | 1.91E-02    | 1.25E-03* | 1.94E-02  | 1.30E-02  | 6.84E-03* | 2.98E-02  | 1.13E-03*   | 2.25E-02  |
| 13                 | .2374     | .2493     | .2622     | .2764       | .2919     | .3090     | .3279     | .3489     | .3724     | .3987       | .4285     |
|                    | 42128.1   | 40115.7   | 38132.6   | 36178.8     | 34254.7   | 32360.2   | 30495.5   | 28660.7   | 26856.1   | 25081.8     | 23337.9   |
|                    | 2.49E-02  | 5.76E-03  | 2.03E-02  | 1.38E-02    | 1.16E-02  | 2.58E-02  | 1.97E-03  | 3.52E-02  | 2.63E-03  | 2.80E-02    | 2.57E-02  |
|                    | 1.2439    | 1.2512    | 1.2794    | 1.2894      | 1.3184    | 1.3289    | 1.3708    | 1.3705    | 1.3711    | 1.4160      | 1.4298    |
|                    | -5.03E-05 | -5.63E-05 | -7.94E-05 | -8.75E-05   | -1.11E-04 | -1.19E-04 | -1.53E-04 | -1.52E-04 | -1.53E-04 | -1.88E-04   | -1.99E-04 |
|                    | 6.36E-03  | 1.59E-03  | 9.55E-03  | 6.74E-03    | 7.77E-03  | 1.68E-02  | 1.76E-03  | 2.60E-02  | 1.61E-03  | 2.11E-02    | 1.74E-02  |
|                    | 6.31E-03  | 1.64E-03* | 9.47E-03  | 6.83E-03    | 7.67E-03  | 1.69E-02  | 1.71E-03* | 2.60E-02  | 1.65E-03* | 2.10E-02    | 1.75E-02  |
| 14                 | .2316     | .2429     | .2552     | .2686       | .2832     | .2993     | .3169     | .3365     | .3583     | .3826       | .4099     |
|                    | 43183.5   | 41171.1   | 39187.9   | 37234.2     | 35310.0   | 33415.5   | 31550.8   | 29716.1   | 27911.5   | 26137.2     | 24393.3   |
|                    | 2.36E-02  | 1.81E-03  | 2.63E-02  | 1.52E-04    | 2.85E-02  | 1.14E-03  | 2.66E-02  | 8.99E-03  | 1.70E-02  | 2.56E-02    | 2.94E-03  |
|                    | 1.2326    | 1.2654    | 1.2665    | 1.3450      | 1.3026    | 1.2969    | 1.3415    | 1.3506    | 1.3844    | 1.3960      | 1.4414    |
|                    | -4.10E-05 | -6.79E-05 | -6.88E-05 | -1.32E-04   | -9.82E-05 | -9.36E-05 | -1.29E-04 | -1.37E-04 | -1.63E-04 | -1.72E-04   | -2.08E-04 |
|                    | 4.30E-03  | 7.87E-04  | 1.01E-02  | ( 1.85E-04) | 1.63E-02  | 5.05E-04  | 1.89E-02  | 5.95E-03  | 1.34E-02  | 1.83E-02    | 2.49E-03  |
|                    | 4.34E-03  | 7.47E-04* | 1.01E-02  | 1.67E-04*   | 1.63E-02  | 5.37E-04* | 1.89E-02  | 6.03E-03* | 1.33E-02  | 1.84E-02    | 2.43E-03* |
| 15                 | .2262     | .2370     | .2487     | .2614       | .2752     | .2904     | .3070     | .3253     | .3456     | .3682       | .3935     |
|                    | 44206.2   | 42193.8   | 40210.6   | 38256.9     | 36332.8   | 34438.2   | 32573.5   | 30738.8   | 28934.2   | 27159.9     | 25416.0   |
|                    | 7.85E-03  | 1.62E-02  | 9.70E-03  | 1.41E-02    | 1.40E-02  | 9.89E-03  | 2.09E-02  | 4.00E-03  | 2.90E-02  | 1.53E-05    | 3.23E-02  |
|                    | 1.2204    | 1.2449    | 1.2531    | 1.2796      | 1.2884    | 1.3170    | 1.3262    | 1.3612    | 1.3663    | 1.6553      | 1.4095    |
|                    | -3.08E-05 | -5.11E-05 | -5.79E-05 | -7.95E-05   | -8.67E-05 | -1.10E-04 | -1.17E-04 | -1.45E-04 | -1.49E-04 | -3.66E-04   | -1.83E-04 |
|                    | 8.72E-04  | 4.29E-03  | 2.85E-03  | 6.74E-03    | 6.81E-03  | 6.58E-03  | 1.34E-02  | 3.30E-03  | 2.11E-02  | ( 5.54E-05) | 2.40E-02  |
|                    | 9.12E-04* | 4.23E-03  | 2.92E-03* | 6.65E-03    | 6.89E-03  | 6.49E-03* | 1.35E-02  | 3.23E-03* | 2.11E-02  | 4.95E-05*   | 2.40E-02  |

Table 2. Radiative transition parameters for  $N_2 A^3\Sigma_u^+ - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v',v''}$  ( $\mu\text{m}$ ),  $\nu_{v',v''}$  ( $\text{cm}^{-1}$ ),  $q_{v',v''}$ ,  $\bar{r}_{v',v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v',v''})$  (electric dipole moment atomic units),  $A_{v',v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v',v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \backslash V''$ | 0         | 1        | 2         | 3           | 4        | 5           | 6         | 7           | 8           | 9           | 10          |
|---------------------|-----------|----------|-----------|-------------|----------|-------------|-----------|-------------|-------------|-------------|-------------|
| 16                  | .1444     | .1494    | .1548     | .1604       | .1664    | .1728       | .1796     | .1868       | .1945       | .2028       | .2117       |
|                     | 69244.2   | 66913.8  | 64612.2   | 62339.4     | 60095.3  | 57880.1     | 55693.6   | 53536.0     | 51407.3     | 49307.5     | 47236.8     |
|                     | 2.76E-02  | 4.41E-02 | 2.97E-03  | 2.03E-02    | 1.45E-02 | 7.01E-03    | 2.06E-02  | 1.69E-03    | 2.25E-02    | 1.92E-04    | 2.28E-02    |
|                     | 1.0606    | 1.0743   | 1.0912    | 1.1004      | 1.1173   | 1.1244      | 1.1440    | 1.1457      | 1.1722      | 1.1517      | 1.2022      |
|                     | 1.05E-04  | 9.35E-05 | 7.88E-05  | 7.08E-05    | 5.63E-05 | 5.02E-05    | 3.34E-05  | 3.20E-05    | 9.52E-06    | 2.69E-05    | -1.57E-05   |
|                     | 1.38E-01  | 1.56E-01 | 6.71E-03  | 3.34E-02    | 1.35E-02 | 4.63E-03    | 5.38E-03  | 3.58E-04    | 3.75E-04    | ( 2.24E-05) | 7.97E-04    |
|                     | 1.38E-01  | 1.56E-01 | 6.83E-03* | 3.32E-02    | 1.36E-02 | 4.54E-03*   | 5.42E-03  | 3.30E-04*   | 3.83E-04    | 1.52E-05*   | 7.96E-04    |
| 17                  | .1425     | .1473    | .1525     | .1580       | .1638    | .1700       | .1765     | .1835       | .1910       | .1990       | .2075       |
|                     | 70198.4   | 67868.0  | 65566.4   | 63293.6     | 61049.6  | 58834.3     | 56647.8   | 54490.2     | 52361.5     | 50261.8     | 48191.0     |
|                     | 2.16E-02  | 4.32E-02 | 8.08E-03  | 1.20E-02    | 2.08E-02 | 1.00E-03    | 2.28E-02  | 4.91E-04    | 2.00E-02    | 3.24E-03    | 1.66E-02    |
|                     | 1.0552    | 1.0687   | 1.0836    | 1.0942      | 1.1105   | 1.1100      | 1.1367    | 1.1722      | 1.1640      | 1.1875      | 1.1931      |
|                     | 1.10E-04  | 9.84E-05 | 8.54E-05  | 7.62E-05    | 6.21E-05 | 6.26E-05    | 3.97E-05  | 9.52E-06    | 1.65E-05    | -3.36E-06   | -8.06E-06   |
|                     | 1.23E-01  | 1.77E-01 | 2.24E-02  | 2.38E-02    | 2.47E-02 | 1.08E-03    | 8.80E-03  | ( 9.72E-06) | 1.05E-03    | ( 6.28E-06) | 1.63E-04    |
|                     | 1.22E-01  | 1.77E-01 | 2.26E-02* | 2.36E-02    | 2.49E-02 | 1.03E-03*   | 8.80E-03  | 1.49E-05*   | 1.04E-03    | 3.24E-06*   | 1.72E-04    |
| 18                  | .1406     | .1454    | .1504     | .1557       | .1614    | .1674       | .1737     | .1805       | .1877       | .1954       | .2036       |
|                     | 71116.5   | 68786.1  | 66484.6   | 64211.7     | 61967.7  | 59752.4     | 57565.9   | 55408.3     | 53279.6     | 51179.9     | 49109.1     |
|                     | 1.68E-02  | 4.06E-02 | 1.39E-02  | 5.30E-03    | 2.35E-02 | 3.15E-04    | 1.89E-02  | 5.54E-03    | 1.17E-02    | 1.15E-02    | 6.18E-03    |
|                     | 1.0501    | 1.0634   | 1.0775    | 1.0882      | 1.1043   | 1.1394      | 1.1298    | 1.1502      | 1.1557      | 1.1761      | 1.1829      |
|                     | 1.15E-04  | 1.03E-04 | 9.07E-05  | 8.14E-05    | 6.75E-05 | 3.74E-05    | 4.56E-05  | 2.02E-05    | 2.35E-05    | 6.23E-06    | 5.03E-07    |
|                     | 1.07E-01  | 1.89E-01 | 4.53E-02  | 1.26E-02    | 3.43E-02 | ( 1.27E-04) | 1.01E-02  | 1.01E-03    | 1.31E-03    | ( 8.07E-05) | ( 2.50E-07) |
|                     | 1.07E-01  | 1.89E-01 | 4.56E-02  | 1.24E-02    | 3.44E-02 | 1.43E-04*   | 1.01E-02  | 1.05E-03*   | 1.27E-03    | 8.99E-05    | 2.41E-08*   |
| 19                  | .1389     | .1435    | .1484     | .1536       | .1591    | .1649       | .1711     | .1777       | .1846       | .1921       | .2000       |
|                     | 71997.1   | 69666.7  | 67365.1   | 65092.3     | 62848.3  | 60633.0     | 58446.5   | 56288.9     | 54160.2     | 52060.5     | 49989.7     |
|                     | 1.29E-02  | 3.69E-02 | 1.92E-02  | 1.31E-03    | 2.23E-02 | 3.56E-03    | 1.20E-02  | 1.21E-02    | 3.74E-03    | 1.73E-02    | 3.17E-04    |
|                     | 1.0453    | 1.0583   | 1.0719    | 1.0818      | 1.0986   | 1.1176      | 1.1231    | 1.1417      | 1.1457      | 1.1681      | 1.1546      |
|                     | 1.19E-04  | 1.07E-04 | 9.56E-05  | 8.70E-05    | 7.24E-05 | 5.60E-05    | 5.13E-05  | 3.54E-05    | 3.20E-05    | 1.30E-05    | 2.44E-05    |
|                     | 9.22E-02  | 1.95E-01 | 7.23E-02  | 3.69E-03    | 3.92E-02 | 3.36E-03    | 8.53E-03  | 3.66E-03    | 8.21E-04    | 5.55E-04    | ( 3.19E-05) |
|                     | 9.21E-02  | 1.95E-01 | 7.25E-02  | 3.61E-03*   | 3.91E-02 | 3.44E-03*   | 8.45E-03  | 3.71E-03    | 7.84E-04*   | 5.69E-04    | 2.36E-05*   |
| 20                  | .1373     | .1418    | .1466     | .1517       | .1570    | .1627       | .1687     | .1750       | .1818       | .1890       | .1967       |
|                     | 72838.6   | 70508.2  | 68206.6   | 65933.8     | 63689.7  | 61474.5     | 59288.0   | 57130.4     | 55001.7     | 52901.9     | 50831.2     |
|                     | 9.93E-03  | 3.27E-02 | 2.32E-02  | 3.28E-06    | 1.85E-02 | 8.38E-03    | 5.46E-03  | 1.64E-02    | 1.32E-04    | 1.72E-02    | 1.50E-03    |
|                     | 1.0406    | 1.0535   | 1.0667    | 1.0384      | 1.0934   | 1.1098      | 1.1159    | 1.1349      | 1.1052      | 1.1608      | 1.1876      |
|                     | 1.23E-04  | 1.12E-04 | 1.00E-04  | 1.25E-04    | 7.69E-05 | 6.27E-05    | 5.75E-05  | 4.12E-05    | 6.67E-05    | 1.92E-05    | -3.45E-06   |
|                     | 7.84E-02  | 1.93E-01 | 9.98E-02  | ( 1.98E-05) | 3.81E-02 | 1.03E-02    | 5.08E-03  | 6.99E-03    | ( 1.32E-04) | 1.27E-03    | ( 3.15E-06) |
|                     | 7.82E-02* | 1.93E-01 | 1.00E-01  | 1.39E-05*   | 3.81E-02 | 1.05E-02*   | 4.99E-03* | 7.02E-03    | 1.15E-04*   | 1.26E-03    | 1.12E-06*   |
| 21                  | .1358     | .1402    | .1449     | .1498       | .1551    | .1606       | .1664     | .1726       | .1792       | .1862       | .1937       |
|                     | 73639.2   | 71308.8  | 69007.3   | 66734.4     | 64490.4  | 62275.1     | 60088.6   | 57931.0     | 55802.3     | 53702.6     | 51631.8     |
|                     | 7.58E-03  | 2.83E-02 | 2.58E-02  | 8.27E-04    | 1.35E-02 | 1.27E-02    | 1.29E-03  | 1.68E-02    | 1.10E-03    | 1.26E-02    | 6.64E-03    |
|                     | 1.0362    | 1.0489   | 1.0619    | 1.0764      | 1.0885   | 1.1038      | 1.1060    | 1.1289      | 1.1561      | 1.1539      | 1.1746      |
|                     | 1.27E-04  | 1.16E-04 | 1.04E-04  | 9.17E-05    | 8.11E-05 | 6.79E-05    | 6.60E-05  | 4.63E-05    | 2.31E-05    | 2.50E-05    | 7.49E-06    |
|                     | 6.58E-02  | 1.86E-01 | 1.25E-01  | 2.79E-03    | 3.22E-02 | 1.91E-02    | 1.65E-03  | 9.48E-03    | ( 1.39E-04) | 1.65E-03    | ( 6.94E-05) |
|                     | 6.57E-02* | 1.86E-01 | 1.25E-01  | 2.87E-03*   | 3.20E-02 | 1.92E-02    | 1.59E-03* | 9.48E-03    | 1.55E-04*   | 1.62E-03    | 7.99E-05*   |

Table 2. Radiative transition parameters for  $N_2 A^3\Sigma_u^+ - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 11        | 12         | 13        | 14         | 15        | 16         | 17        | 18        | 19        | 20        | 21        |
|---------------------|-----------|------------|-----------|------------|-----------|------------|-----------|-----------|-----------|-----------|-----------|
| 16                  | .2213     | .2316      | .2427     | .2548      | .2679     | .2823      | .2980     | .3152     | .3342     | .3553     | .3787     |
|                     | 45195.2   | 43182.8    | 41199.7   | 39246.0    | 37321.8   | 35427.3    | 33562.6   | 31727.8   | 29923.2   | 28148.9   | 26405.0   |
|                     | 2.40E-07  | 2.29E-02   | 1.66E-07  | 2.37E-02   | 1.10E-04  | 2.45E-02   | 1.15E-03  | 2.40E-02  | 4.97E-03  | 2.01E-02  | 1.40E-02  |
|                     | .1252     | 1.2339     | 2.8299    | 1.2670     | 1.2132    | 1.3019     | 1.2959    | 1.3394    | 1.3450    | 1.3802    | 1.3898    |
|                     | 1.05E-03  | -4.20E-05  | -1.01E-03 | -6.93E-05  | -2.49E-05 | -9.76E-05  | -9.28E-05 | -1.28E-04 | -1.32E-04 | -1.60E-04 | -1.68E-04 |
| (3.27E-05)          | 4.41E-03  | (1.60E-05) | 9.26E-03  | (4.78E-06) | 1.40E-02  | 5.04E-04   | 1.69E-02  | 3.14E-03  | 1.55E-02  | 9.79E-03  |           |
|                     | 1.62E-05* | 4.41E-03   | 2.13E-05* | 9.25E-03   | 8.78E-06* | 1.40E-02   | 5.35E-04* | 1.68E-02  | 3.21E-03* | 1.54E-02  | 9.88E-03  |
| 17                  | .2167     | .2266      | .2372     | .2488      | .2613     | .2749      | .2897     | .3060     | .3239     | .3436     | .3655     |
|                     | 46149.4   | 44137.0    | 42153.9   | 40200.2    | 38276.0   | 36381.5    | 34516.8   | 32682.0   | 30877.4   | 29103.1   | 27359.3   |
|                     | 5.95E-03  | 1.44E-02   | 7.55E-03  | 1.40E-02   | 7.84E-03  | 1.54E-02   | 6.72E-03  | 1.87E-02  | 4.15E-03  | 2.37E-02  | 1.01E-03  |
|                     | 1.2160    | 1.2237     | 1.2480    | 1.2554     | 1.2819    | 1.2889     | 1.3180    | 1.3251    | 1.3589    | 1.3638    | 1.4168    |
|                     | -2.72E-05 | -3.36E-05  | -5.37E-05 | -5.97E-05  | -8.14E-05 | -8.71E-05  | -1.11E-04 | -1.16E-04 | -1.43E-04 | -1.47E-04 | -1.89E-04 |
|                     | 5.84E-04  | 1.89E-03   | 2.20E-03  | 4.39E-03   | 3.94E-03  | 7.62E-03   | 4.56E-03  | 1.19E-02  | 3.38E-03  | 1.70E-02  | 9.98E-04  |
|                     | 5.52E-04* | 1.93E-03   | 2.14E-03* | 4.45E-03   | 3.86E-03* | 7.69E-03   | 4.48E-03* | 1.20E-02  | 3.31E-03* | 1.71E-02  | 9.62E-04* |
| 18                  | .2125     | .2220      | .2322     | .2432      | .2551     | .2681      | .2822     | .2976     | .3145     | .3331     | .3536     |
|                     | 47067.5   | 45055.1    | 43072.0   | 41118.3    | 39194.1   | 37299.6    | 35434.9   | 33600.1   | 31795.5   | 30021.2   | 28277.4   |
|                     | 1.55E-02  | 3.14E-03   | 1.77E-02  | 1.83E-03   | 1.91E-02  | 1.54E-03   | 2.00E-02  | 2.08E-03  | 2.03E-02  | 3.94E-03  | 1.91E-02  |
|                     | 1.2051    | 1.2105     | 1.2363    | 1.2371     | 1.2688    | 1.2661     | 1.3027    | 1.3022    | 1.3390    | 1.3429    | 1.3782    |
|                     | 1.01E-05  | 2.26E-05   | 4.40E-05  | 4.47E-05   | -7.07E-05 | -6.85E-05  | -9.83E-05 | -9.79E-05 | -1.27E-04 | -1.31E-04 | -1.58E-04 |
|                     | 7.14E-04  | 1.98E-04   | 3.70E-03  | 3.44E-04   | 7.75E-03  | 5.07E-04   | 1.16E-02  | 1.02E-03  | 1.43E-02  | 2.46E-03  | 1.47E-02  |
|                     | 6.97E-04  | 2.19E-04*  | 3.67E-03  | 3.71E-04*  | 7.71E-03  | 5.39E-04*  | 1.15E-02  | 1.06E-03* | 1.42E-02  | 2.51E-03* | 1.46E-02  |
| 19                  | .2086     | .2177      | .2275     | .2381      | .2495     | .2619      | .2754     | .2900     | .3060     | .3236     | .3430     |
|                     | 47948.1   | 45935.7    | 43952.6   | 41998.9    | 40074.7   | 38180.2    | 36315.5   | 34480.7   | 32676.1   | 30901.8   | 29158.0   |
|                     | 1.85E-02  | 2.31E-04   | 1.79E-02  | 1.40E-03   | 1.70E-02  | 2.55E-03   | 1.70E-02  | 3.08E-03  | 1.81E-02  | 2.71E-03  | 2.05E-02  |
|                     | 1.1966    | 1.2442     | 1.2269    | 1.2586     | 1.2583    | 1.2892     | 1.2908    | 1.3231    | 1.3257    | 1.3613    | 1.3631    |
|                     | -1.10E-05 | -5.05E-05  | -3.62E-05 | -6.24E-05  | -6.21E-05 | -8.73E-05  | -8.86E-05 | -1.15E-04 | -1.17E-04 | -1.45E-04 | -1.47E-04 |
|                     | 3.34E-04  | (7.73E-05) | 2.69E-03  | 5.45E-04   | 5.72E-03  | 1.46E-03   | 8.65E-03  | 2.25E-03  | 1.16E-02  | 2.27E-03  | 1.47E-02  |
|                     | 3.31E-04  | 6.48E-05*  | 2.70E-03  | 5.13E-04*  | 5.75E-03  | 1.41E-03*  | 8.70E-03  | 2.19E-03* | 1.17E-02  | 2.22E-03* | 1.48E-02  |
| 20                  | .2050     | .2138      | .2232     | .2334      | .2444     | .2563      | .2691     | .2831     | .2984     | .3150     | .3333     |
|                     | 48789.6   | 46777.2    | 44794.1   | 42840.4    | 40916.2   | 39021.7    | 37157.0   | 35322.2   | 33517.6   | 31743.3   | 29999.4   |
|                     | 1.39E-02  | 5.46E-03   | 9.80E-03  | 9.30E-03   | 6.75E-03  | 1.22E-02   | 4.98E-03  | 1.43E-02  | 4.32E-03  | 1.56E-02  | 4.73E-03  |
|                     | 1.1885    | 1.2108     | 1.2176    | 1.2405     | 1.2470    | 1.2723     | 1.2768    | 1.3053    | 1.3091    | 1.3404    | 1.3450    |
|                     | -4.20E-06 | -2.29E-05  | -2.85E-05 | -4.75E-05  | -5.28E-05 | -7.36E-05  | -7.73E-05 | -1.00E-04 | -1.03E-04 | -1.29E-04 | -1.32E-04 |
|                     | 3.85E-05  | 3.94E-04   | 9.68E-04  | 2.23E-03   | 1.74E-03  | 5.31E-03   | 2.06E-03  | 8.57E-03  | 2.35E-03  | 1.11E-02  | 3.01E-03  |
|                     | 4.20E-05  | 3.68E-04*  | 9.99E-04* | 2.18E-03*  | 1.79E-03* | 5.26E-03   | 2.11E-03* | 8.51E-03  | 2.41E-03* | 1.11E-02  | 3.07E-03* |
| 21                  | .2017     | .2102      | .2193     | .2291      | .2397     | .2511      | .2635     | .2768     | .2914     | .3073     | .3247     |
|                     | 49590.2   | 47577.8    | 45594.7   | 43641.0    | 41716.8   | 39822.3    | 37957.6   | 36122.8   | 34318.2   | 32543.9   | 30800.1   |
|                     | 6.43E-03  | 1.20E-02   | 2.13E-03  | 1.51E-02   | 2.93E-04  | 1.65E-02   | 2.42E-05  | 1.70E-02  | 3.97E-04  | 1.76E-02  | 7.66E-04  |
|                     | 1.1798    | 1.2014     | 1.2049    | 1.2311     | 1.2140    | 1.2623     | 1.4159    | 1.2943    | 1.3493    | 1.3281    | 1.3758    |
|                     | 3.11E-06  | -1.50E-05  | -1.79E-05 | -3.97E-05  | -2.55E-05 | -6.54E-05  | -1.88E-04 | -9.15E-05 | -1.36E-04 | -1.19E-04 | -1.57E-04 |
| (1.03E-05)          | 3.94E-04  | (8.79E-05) | 2.68E-03  | (1.87E-05) | 6.01E-03  | (6.30E-05) | 9.08E-03  | 3.98E-04  | 1.16E-02  | 7.41E-04  |           |
|                     | 7.14E-06* | 3.78E-04   | 1.01E-04* | 2.67E-03   | 2.55E-05* | 6.00E-03   | 5.45E-05* | 9.09E-03  | 3.75E-04* | 1.16E-02  | 7.10E-04* |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 3. Radiative transition parameters for  $N_2$   $B\ ^3\Pi_g - A\ ^3\Sigma_u^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $v'\backslash v''$ | 0         | 1         | 2         | 3         | 4         | 5         | 6         | 7          | 8           | 9          | 10       |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|-------------|------------|----------|
| 0                  | 1.0469    | 1.2317    | 1.4895    | 1.8739    | 2.5084    | 3.7523    | 7.2916    | 94.1292    | -8.8467     | -4.2771    | -2.8438  |
|                    | 9552.0    | 8119.1    | 6713.8    | 5336.3    | 3986.7    | 2665.0    | 1371.4    | 106.2      | -1130.4     | -2338.0    | -3516.4  |
| 4.01E-01           | 3.30E-01  | 1.66E-01  | 6.72E-02  | 2.41E-02  | 8.09E-03  | 2.62E-03  | 8.31E-04  | 2.63E-04   | 8.36E-05    | 2.69E-05   |          |
| 1.2534             | 1.2160    | 1.1827    | 1.1526    | 1.1253    | 1.1002    | 1.0772    | 1.0558    | 1.0360     | 1.0175      | 1.0004     |          |
| 2.68E-01           | 2.76E-01  | 2.83E-01  | 2.88E-01  | 2.93E-01  | 2.97E-01  | 3.01E-01  | 3.04E-01  | 3.07E-01   | 3.09E-01    | 3.11E-01   |          |
| 5.09E+04           | 2.73E+04  | 8.15E+03  | 1.72E+03  | 2.66E+02  | 2.75E+01  | 1.24E+00  | 1.87E-04  | -1.45E-01  | -4.14E-01   | -4.59E-01  |          |
| 5.08E+04           | 2.73E+04  | 8.16E+03  | 1.73E+03  | 2.68E+02  | 2.76E+01* | 1.25E+00* | 1.88E-04* | -1.46E-01* | -4.18E-01*  | -4.64E-01* |          |
| 1                  | .8883     | 1.0179    | 1.1878    | 1.4201    | 1.7569    | 2.2882    | 3.2502    | 5.5202     | 17.3933     | -15.8042   | -5.5215  |
|                    | 11257.3   | 9824.4    | 8419.1    | 7041.6    | 5692.0    | 4370.3    | 3076.8    | 1811.5     | 574.9       | -632.7     | -1811.1  |
| 4.00E-01           | 2.87E-03  | 1.59E-01  | 1.96E-01  | 1.30E-01  | 6.57E-02  | 2.86E-02  | 1.14E-02  | 4.31E-03   | 1.59E-03    | 5.78E-04   |          |
| 1.2979             | 1.3088    | 1.2273    | 1.1920    | 1.1613    | 1.1336    | 1.1085    | 1.0854    | 1.0640     | 1.0443      | 1.0259     |          |
| 2.50E-01           | 2.56E-01  | 2.74E-01  | 2.81E-01  | 2.87E-01  | 2.92E-01  | 2.96E-01  | 3.00E-01  | 3.03E-01   | 3.06E-01    | 3.08E-01   |          |
| 7.70E+04           | 3.60E+02  | 1.44E+04  | 1.09E+04  | 4.00E+03  | 9.46E+02  | 1.48E+02  | 1.23E+01  | 1.52E+01   | -1.52E+01   | -1.32E+00  |          |
| 7.70E+04           | 3.45E+02* | 1.43E+04  | 1.09E+04  | 4.01E+03  | 9.49E+02  | 1.48E+02  | 1.24E+01  | 1.54E-01*  | -1.54E-01*  | -1.33E+00* |          |
| 2                  | .7732     | .8695     | .9905     | 1.1471    | 1.3572    | 1.6538    | 2.1030    | 2.8671     | 4.4420      | 9.5828     | -74.1757 |
|                    | 12933.5   | 11500.7   | 10095.4   | 8717.9    | 7368.3    | 6046.6    | 4753.0    | 3487.8     | 2251.2      | 1043.5     | -134.8   |
| 1.61E-01           | 2.76E-01  | 6.90E-02  | 2.19E-02  | 1.24E-01  | 1.43E-01  | 1.01E-01  | 5.63E-02  | 2.74E-02   | 1.22E-02    | 5.20E-03   |          |
| 1.3475             | 1.3087    | 1.2571    | 1.2486    | 1.2027    | 1.1705    | 1.1424    | 1.1170    | 1.0938     | 1.0725      | 1.0528     |          |
| 2.46E-01           | 2.56E-01  | 2.67E-01  | 2.69E-01  | 2.79E-01  | 2.85E-01  | 2.90E-01  | 2.95E-01  | 2.98E-01   | 3.02E-01    | 3.05E-01   |          |
| 4.28E+04           | 5.55E+04  | 1.03E+04  | 2.13E+03  | 7.82E+03  | 5.19E+03  | 1.85E+03  | 4.20E+02  | 5.63E+01   | 2.57E+00    | -4.79E-03  |          |
| 4.29E+04           | 5.54E+04  | 1.03E+04  | 2.10E+03  | 7.79E+03  | 5.19E+03  | 1.85E+03  | 4.22E+02  | 5.66E+01   | 2.58E+00    | -4.83E-03* |          |
| 3                  | .6858     | .7606     | .8516     | .9648     | 1.1092    | 1.2997    | 1.5624    | 1.9474     | 2.5651      | 3.7163     | 6.6117   |
|                    | 14580.8   | 13147.9   | 11742.7   | 10365.2   | 9015.6    | 7693.9    | 6400.3    | 5135.1     | 3898.5      | 2690.8     | 1512.5   |
| 3.39E-02           | 2.77E-01  | 9.61E-02  | 1.52E-01  | 5.19E-03  | 4.22E-02  | 1.07E-01  | 1.11E-01  | 8.00E-02   | 4.73E-02    | 2.49E-02   |          |
| 1.4035             | 1.3567    | 1.3235    | 1.2708    | 1.1981    | 1.2175    | 1.1808    | 1.1516    | 1.1258     | 1.1025      | 1.0811     |          |
| 2.32E-01           | 2.44E-01  | 2.52E-01  | 2.64E-01  | 2.80E-01  | 2.76E-01  | 2.83E-01  | 2.89E-01  | 2.93E-01   | 2.97E-01    | 3.00E-01   |          |
| 1.15E+04           | 7.61E+04  | 2.00E+04  | 2.39E+04  | 6.02E+02  | 2.96E+03  | 4.58E+03  | 2.54E+03  | 8.26E+02   | 1.65E+02    | 1.58E+01   |          |
| 1.16E+04           | 7.61E+04  | 1.99E+04  | 2.40E+04  | 6.24E+02* | 2.93E+03  | 4.56E+03  | 2.54E+03  | 8.28E+02   | 1.66E+02    | 1.58E+01   |          |
| 4                  | .6173     | .6772     | .7484     | .8345     | .9404     | 1.0739    | 1.2471    | 1.4807     | 1.8126      | 2.3207     | 3.1941   |
|                    | 16199.1   | 14766.2   | 13361.0   | 11983.5   | 10633.9   | 9312.2    | 8018.6    | 6753.4     | 5516.8      | 4309.1     | 3130.8   |
| 4.04E-03           | 9.67E-02  | 2.98E-01  | 7.60E-03  | 1.51E-01  | 5.12E-02  | 2.19E-03  | 5.47E-02  | 9.36E-02   | 8.96E-02    | 6.49E-02   |          |
| 1.4684             | 1.4124    | 1.3666    | 1.3676    | 1.2827    | 1.2353    | 1.2740    | 1.1933    | 1.1617     | 1.1352      | 1.1116     |          |
| 2.16E-01           | 2.30E-01  | 2.42E-01  | 2.41E-01  | 2.62E-01  | 2.72E-01  | 2.64E-01  | 2.81E-01  | 2.87E-01   | 2.92E-01    | 2.96E-01   |          |
| 1.62E+03           | 3.34E+04  | 8.41E+04  | 1.54E+03  | 2.52E+04  | 6.20E+03  | 1.59E+02  | 2.69E+03  | 2.62E+03   | 1.23E+03    | 3.53E+02   |          |
| 1.63E+03*          | 3.35E+04  | 8.40E+04  | 1.50E+03* | 2.52E+04  | 6.26E+03  | 1.50E+02* | 2.67E+03  | 2.61E+03   | 1.23E+03    | 3.54E+02   |          |
| 5                  | .5622     | .6114     | .6689     | .7368     | .8181     | .9173     | 1.0408    | 1.1987     | 1.4072      | 1.6954     | 2.1186   |
|                    | 17788.4   | 16355.5   | 14950.3   | 13572.8   | 12223.1   | 10901.5   | 9607.9    | 8342.7     | 7106.1      | 5898.4     | 4720.1   |
| 2.74E-04           | 1.62E-02  | 1.69E-01  | 2.44E-01  | 1.04E-02  | 9.55E-02  | 9.48E-02  | 8.77E-03  | 1.39E-02   | 5.93E-02    | 8.09E-02   |          |
| 1.5458             | 1.4772    | 1.4215    | 1.3775    | 1.2875    | 1.2959    | 1.2492    | 1.1919    | 1.2143     | 1.1733      | 1.1453     |          |
| 1.96E-01           | 2.14E-01  | 2.28E-01  | 2.39E-01  | 2.60E-01  | 2.59E-01  | 2.69E-01  | 2.81E-01  | 2.76E-01   | 2.85E-01    | 2.90E-01   |          |
| 1.19E+02           | 6.57E+03  | 5.93E+04  | 7.05E+04  | 2.62E+03  | 1.68E+04  | 1.23E+04  | 8.15E+02  | 7.74E+02   | 2.00E+03    | 1.45E+03   |          |
| 1.20E+02*          | 6.59E+03  | 5.95E+04  | 7.03E+04  | 2.69E+03  | 1.66E+04  | 1.24E+04  | 8.37E+02* | 7.58E+02   | 1.98E+03    | 1.45E+03   |          |
| 6                  | .5168     | .5582     | .6057     | .6608     | .7255     | .8025     | .8954     | 1.0098     | 1.1539      | 1.3407     | 1.5923   |
|                    | 19348.6   | 17915.7   | 16510.5   | 15133.0   | 13783.3   | 12461.7   | 11168.1   | 9902.9     | 8666.3      | 7458.6     | 6280.3   |
| 1.01E-05           | 1.43E-03  | 3.89E-02  | 2.30E-01  | 1.57E-01  | 5.81E-02  | 3.55E-02  | 1.04E-01  | 3.95E-02   | 1.75E-08    | 2.48E-02   |          |
| 1.6441             | 1.5549    | 1.4862    | 1.4310    | 1.3903    | 1.3214    | 1.3149    | 1.2614    | 1.2181     | 22.1050     | 1.1888     |          |
| 1.70E-01           | 1.93E-01  | 2.11E-01  | 2.25E-01  | 2.36E-01  | 2.53E-01  | 2.54E-01  | 2.66E-01  | 2.76E-01   | 0.00E+00    | 2.82E-01   |          |
| 4.26E+00           | 6.20E+02  | 1.58E+04  | 8.19E+04  | 4.62E+04  | 1.45E+04  | 6.46E+03  | 1.46E+04  | 3.95E+03   | ( 0.00E+00) | 9.86E+02   |          |
| 4.23E+00*          | 6.22E+02* | 1.59E+04  | 8.21E+04  | 4.60E+04  | 1.47E+04  | 6.37E+03  | 1.46E+04  | 3.99E+03   | 6.68E-01*   | 9.72E+02   |          |
| 7                  | .4789     | .5142     | .5543     | .6001     | .6530     | .7147     | .7875     | .8746      | .9806       | 1.1124     | 1.2802   |
|                    | 20879.7   | 19446.8   | 18041.6   | 16664.1   | 15314.4   | 13992.7   | 12699.2   | 11434.0    | 10197.4     | 8989.7     | 7811.3   |
| 1.74E-07           | 6.42E-05  | 4.32E-03  | 7.16E-02  | 2.66E-01  | 7.47E-02  | 1.06E-01  | 3.08E-03  | 8.16E-02   | 6.78E-02    | 1.08E-02   |          |
| 1.7837             | 1.6539    | 1.5641    | 1.4954    | 1.4410    | 1.4071    | 1.3368    | 1.3797    | 1.2744     | 1.2324      | 1.1840     |          |
| 1.35E-01           | 1.67E-01  | 1.91E-01  | 2.09E-01  | 2.23E-01  | 2.32E-01  | 2.49E-01  | 2.38E-01  | 2.63E-01   | 2.73E-01    | 2.83E-01   |          |
| 5.85E-02           | 2.68E+01  | 1.87E+03  | 2.93E+04  | 9.60E+04  | 2.22E+04  | 2.72E+04  | 5.30E+02  | 1.22E+04   | 7.42E+03    | 8.34E+02   |          |
| 5.58E-02*          | 2.66E+01* | 1.87E+03* | 2.93E+04  | 9.61E+04  | 2.20E+04  | 2.73E+04  | 5.02E+02* | 1.21E+04   | 7.44E+03    | 8.54E+02   |          |

Table 3. Radiative transition parameters for  $N_2$   $B\ ^3\Pi_g - A\ ^3\Sigma_u^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . — Continued

| $V'\backslash V''$ | 11         | 12         | 13         | 14         | 15         | 16         | 17         | 18         | 19         | 20         | 21       |
|--------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|----------|
| 0                  | -2.1436    | -1.7292    | -1.4555    | -1.2617    | -1.1175    | -1.0063    | -.9181     | -.8468     | -.7880     | -.7390     | -.6977   |
|                    | -4665.0    | -5783.1    | -6870.3    | -7925.7    | -8948.4    | -9937.4    | -10891.6   | -11809.7   | -12690.3   | -13531.8   | -14332.4 |
| 8.85E-06           | 2.99E-06   | 1.04E-06   | 3.78E-07   | 1.43E-07   | 5.61E-08   | 2.29E-08   | 9.63E-09   | 4.12E-09   | 1.76E-09   | 7.24E-10   |          |
|                    | .9847      | .9706      | .9581      | .9475      | .9387      | .9318      | .9263      | .9215      | .9164      | .9096      | .8987    |
| 3.13E-01           | 3.14E-01   | 3.15E-01   | 3.16E-01   | 3.17E-01   | 3.18E-01   | 3.18E-01   | 3.18E-01   | 3.19E-01   | 3.19E-01   | 3.20E-01   |          |
| -3.56E-01          | -2.31E-01  | -1.36E-01  | -7.63E-02  | -4.16E-02  | -2.25E-02  | -1.21E-02  | -6.52E-03  | -3.47E-03  | -1.80E-03  | -8.83E-04  |          |
| -3.61E-01*         | -2.34E-01* | -1.38E-01* | -7.73E-02* | -4.21E-02* | -2.27E-02* | -1.22E-02* | -6.57E-03* | -3.49E-03* | -1.81E-03* | -8.90E-04* |          |
| 1                  | -3.3788    | -2.4523    | -1.9361    | -1.6076    | -1.3806    | -1.2148    | -1.0886    | -0.9897    | -0.9103    | -0.8456    | -0.7919  |
|                    | -2959.6    | -4077.8    | -5165.0    | -6220.4    | -7243.1    | -8232.1    | -9186.3    | -10104.4   | -10985.0   | -11826.5   | -12627.1 |
| 2.10E-04           | 7.71E-05   | 2.88E-05   | 1.10E-05   | 4.31E-06   | 1.74E-06   | 7.25E-07   | 3.10E-07   | 1.35E-07   | 5.94E-08   | 2.57E-08   |          |
| 1.0090             | .9934      | .9792      | .9665      | .9553      | .9456      | .9373      | .9300      | .9231      | .9159      | .9067      |          |
| 3.10E-01           | 3.12E-01   | 3.13E-01   | 3.15E-01   | 3.16E-01   | 3.17E-01   | 3.17E-01   | 3.18E-01   | 3.18E-01   | 3.19E-01   | 3.19E-01   |          |
| -2.12E+00          | -2.06E+00  | -1.58E+00  | -1.06E+00  | -6.61E-01  | -3.94E-01  | -2.29E-01  | -1.31E-01  | -7.36E-02  | -4.04E-02  | -2.14E-02  |          |
| -2.15E+00*         | -2.09E+00* | -1.60E+00* | -1.07E+00* | -6.69E-01* | -3.99E-01* | -2.32E-01* | -1.32E-01* | -7.43E-02* | -4.08E-02* | -2.16E-02* |          |
| 2                  | -7.7920    | -4.1640    | -2.8664    | -2.2007    | -1.7964    | -1.5254    | -1.3316    | -1.1865    | -1.0743    | -0.9852    | -0.9132  |
|                    | -1283.4    | -2401.6    | -3488.7    | -4544.1    | -5566.8    | -6555.8    | -7510.0    | -8428.2    | -9308.7    | -10150.2   | -10950.8 |
| 2.15E-03           | 8.77E-04   | 3.57E-04   | 1.46E-04   | 6.08E-05   | 2.57E-05   | 1.11E-05   | 4.90E-06   | 2.20E-06   | 9.93E-07   | 4.47E-07   |          |
| 1.0345             | 1.0177     | 1.0021     | .9879      | .9750      | .9634      | .9530      | .9436      | .9349      | .9262      | .9166      |          |
| 3.07E-01           | 3.09E-01   | 3.11E-01   | 3.13E-01   | 3.14E-01   | 3.15E-01   | 3.16E-01   | 3.17E-01   | 3.17E-01   | 3.18E-01   | 3.19E-01   |          |
| -1.74E+00          | -4.70E+00  | -5.94E+00  | -5.44E+00  | -4.19E+00  | -2.92E+00  | -1.90E+00  | -1.19E+00  | -7.25E-01  | -4.26E-01  | -2.41E-01  |          |
| -1.75E+00*         | -4.75E+00* | -6.00E+00* | -5.50E+00* | -4.24E+00* | -2.95E+00* | -1.93E+00* | -1.21E+00* | -7.32E-01* | -4.31E-01* | -2.44E-01* |          |
| 3                  | 27.4786    | -13.2578   | -5.4305    | -3.4521    | -2.5513    | -2.0373    | -1.7057    | -1.4747    | -1.3052    | -1.1761    | -1.0749  |
|                    | 363.9      | -754.3     | -1841.4    | -2896.8    | -3919.5    | -4908.5    | -5862.7    | -6780.9    | -7661.5    | -8502.9    | -9303.6  |
| 1.22E-02           | 5.68E-03   | 2.58E-03   | 1.16E-03   | 5.21E-04   | 2.35E-04   | 1.07E-04   | 4.93E-05   | 2.30E-05   | 1.08E-05   | 5.06E-06   |          |
| 1.0615             | 1.0433     | 1.0266     | 1.0111     | .9968      | .9838      | .9718      | .9608      | .9505      | .9406      | .9304      |          |
| 3.03E-01           | 3.06E-01   | 3.08E-01   | 3.10E-01   | 3.12E-01   | 3.13E-01   | 3.14E-01   | 3.15E-01   | 3.16E-01   | 3.17E-01   | 3.18E-01   |          |
| 1.09E-01           | -9.24E-01  | -6.20E+00  | -1.10E+01  | -1.23E+01  | -1.10E+01  | -8.62E+00  | -6.18E+00  | -4.18E+00  | -2.70E+00  | -1.67E+00  |          |
| 1.10E-01           | -9.31E-01* | -6.26E+00* | -1.11E+01* | -1.25E+01* | -1.11E+01* | -8.72E+00* | -6.26E+00* | -4.23E+00* | -2.73E+00* | -1.69E+00* |          |
| 4                  | 5.0449     | 11.5737    | -44.8147   | -7.8216    | -4.3455    | -3.0393    | -2.3560    | -1.9370    | -1.6548    | -1.4525    | -1.3012  |
|                    | 1982.2     | 864.0      | -223.1     | -1278.5    | -2301.2    | -3290.2    | -4244.5    | -5162.6    | -6043.2    | -6884.6    | -7685.3  |
| 4.02E-02           | 2.25E-02   | 1.18E-02   | 5.99E-03   | 2.96E-03   | 1.45E-03   | 7.07E-04   | 3.46E-04   | 1.70E-04   | 8.35E-05   | 4.11E-05   |          |
| 1.0901             | 1.0705     | 1.0523     | 1.0356     | 1.0202     | 1.0059     | .9927      | .9805      | .9690      | .9580      | .9471      |          |
| 2.99E-01           | 3.02E-01   | 3.05E-01   | 3.07E-01   | 3.09E-01   | 3.11E-01   | 3.12E-01   | 3.13E-01   | 3.14E-01   | 3.15E-01   | 3.16E-01   |          |
| 5.67E+01           | 2.68E+00   | -4.95E-02  | -4.78E+00  | -1.40E+01  | -2.02E+01  | -2.13E+01  | -1.89E+01  | -1.50E+01  | -1.10E+01  | -7.56E+00  |          |
| 5.69E+01           | 2.70E+00   | -4.98E-02  | -4.82E+00* | -1.41E+01* | -2.04E+01* | -2.16E+01* | -1.91E+01* | -1.52E+01* | -1.11E+01* | -7.65E+00* |          |
| 5                  | 2.7999     | 4.0761     | 7.3199     | 32.1787    | -14.0462   | -5.8790    | -3.7662    | -2.7985    | -2.2452    | -1.8884    | -1.6404  |
|                    | 3571.5     | 2453.3     | 1366.1     | 310.8      | -711.9     | -1701.0    | -2655.2    | -3573.3    | -4453.9    | -5295.4    | -6096.0  |
| 7.35E-02           | 5.39E-02   | 3.47E-02   | 2.05E-02   | 1.15E-02   | 6.28E-03   | 3.34E-03   | 1.76E-03   | 9.22E-04   | 4.81E-04   | 2.50E-04   |          |
| 1.1211             | 1.0995     | 1.0798     | 1.0616     | 1.0449     | 1.0295     | 1.0152     | 1.0019     | .9894      | .9776      | .9661      |          |
| 2.94E-01           | 2.98E-01   | 3.01E-01   | 3.03E-01   | 3.06E-01   | 3.08E-01   | 3.09E-01   | 3.11E-01   | 3.12E-01   | 3.14E-01   | 3.15E-01   |          |
| 5.87E+02           | 1.43E+02   | 1.62E+01   | 1.15E-01   | -1.58E+00  | -1.18E+01  | -2.43E+01  | -3.15E+01  | -3.22E+01  | -2.85E+01  | -2.27E+01  |          |
| 5.87E+02           | 1.43E+02   | 1.63E+01   | 1.16E-01   | -1.59E+00  | -1.19E+01* | -2.45E+01* | -3.18E+01* | -3.25E+01* | -2.88E+01* | -2.30E+01* |          |
| 6                  | 1.9487     | 2.4916     | 3.4172     | 5.3448     | 11.7886    | -71.0500   | -9.1328    | -4.9675    | -3.4558    | -2.6773    | -2.2047  |
|                    | 5131.7     | 4013.5     | 2926.4     | 1871.0     | 848.3      | -140.7     | -1095.0    | -2013.1    | -2893.7    | -3735.1    | -4535.8  |
| 5.83E-02           | 6.96E-02   | 6.14E-02   | 4.57E-02   | 3.06E-02   | 1.91E-02   | 1.14E-02   | 6.60E-03   | 3.75E-03   | 2.10E-03   | 1.17E-03   |          |
| 1.1565             | 1.1313     | 1.1093     | 1.0894     | 1.0712     | 1.0545     | 1.0391     | 1.0248     | 1.0114     | .9987      | .9866      |          |
| 2.88E-01           | 2.92E-01   | 2.96E-01   | 2.99E-01   | 3.02E-01   | 3.04E-01   | 3.06E-01   | 3.08E-01   | 3.10E-01   | 3.11E-01   | 3.13E-01   |          |
| 1.32E+03           | 7.78E+02   | 2.73E+02   | 5.43E+01   | 3.45E+00   | -2.00E-02  | -5.69E+00  | -2.07E+01  | -3.54E+01  | -4.30E+01  | -4.31E+01  |          |
| 1.31E+03           | 7.77E+02   | 2.73E+02   | 5.45E+01   | 3.47E+00   | -2.01E-02  | -5.73E+00  | -2.09E+01* | -3.57E+01* | -4.34E+01* | -4.36E+01* |          |
| 7                  | 1.5009     | 1.8036     | 2.2434     | 2.9394     | 4.2028     | 7.1926     | 22.9296    | -20.7470   | -7.3390    | -4.5371    | -3.3281  |
|                    | 6662.8     | 5544.6     | 4457.4     | 3402.1     | 2379.4     | 1390.3     | 436.1      | -482.0     | -1362.6    | -2204.1    | -3004.7  |
| 3.69E-03           | 3.10E-02   | 5.42E-02   | 5.97E-02   | 5.22E-02   | 3.97E-02   | 2.76E-02   | 1.81E-02   | 1.14E-02   | 6.99E-03   | 4.20E-03   |          |
| 1.2253             | 1.1702     | 1.1425     | 1.1197     | 1.0995     | 1.0812     | 1.0644     | 1.0490     | 1.0346     | 1.0211     | 1.0084     |          |
| 2.74E-01           | 2.85E-01   | 2.90E-01   | 2.94E-01   | 2.98E-01   | 3.00E-01   | 3.03E-01   | 3.05E-01   | 3.07E-01   | 3.09E-01   | 3.10E-01   |          |
| 1.66E+02           | 8.69E+02   | 8.19E+02   | 4.13E+02   | 1.26E+02   | 1.95E+01   | 4.26E-01   | -7.66E-01  | -1.10E+01  | -2.89E+01  | -4.44E+01  |          |
| 1.59E+02*          | 8.60E+02   | 8.15E+02   | 4.12E+02   | 1.26E+02   | 1.96E+01   | 4.28E-01   | -7.70E-01  | -1.11E+01  | -2.91E+01* | -4.48E+01* |          |

Table 3. Radiative transition parameters for  $N_2$   $B\ ^3\Pi_g - A\ ^3\Sigma_u^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . — Continued

| $v'\backslash v''$                                   | 0         | 1           | 2           | 3           | 4           | 5           | 6           | 7         | 8        | 9        | 10     |
|--|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-----------|----------|----------|--------|
| 8  | .4468     | .4774       | .5117       | .5505       | .5947       | .6454       | .7042       | .7730     | .8548    | .9532    | 1.0737 |
| 22381.5  | 20948.6   | 19543.4     | 18165.9     | 16816.2     | 15494.6     | 14201.0     | 12935.8     | 11699.2   | 10491.5  | 9313.2   |        |
| 1.00E-09   | 1.30E-06  | 2.33E-04    | 9.90E-03    | 1.12E-01    | 2.71E-01    | 2.01E-02    | 1.28E-01    | 4.74E-03  | 4.46E-02 | 7.74E-02 |        |
| 2.0299   | 1.7952    | 1.6639      | 1.5736      | 1.5050      | 1.4515      | 1.4385      | 1.3499      | 1.2500    | 1.2902   | 1.2452   |        |
| 8.27E-02   | 1.32E-01  | 1.65E-01    | 1.88E-01    | 2.06E-01    | 2.20E-01    | 2.24E-01    | 2.46E-01    | 2.69E-01  | 2.60E-01 | 2.70E-01 |        |
| ( 1.56E-04)  | 4.25E-01  | 9.59E+01    | 4.26E+03    | 4.58E+04    | 9.91E+04    | 5.82E+03    | 3.39E+04    | 1.11E+03  | 7.05E+03 | 9.22E+03 |        |
| 1.06E-04*  | 4.03E-01* | 9.51E+01*   | 4.27E+03*   | 4.60E+04    | 9.91E+04    | 5.71E+03    | 3.40E+04    | 1.16E+03* | 6.97E+03 | 9.22E+03 |        |
| 9  | .4192     | .4460       | .4758       | .5092       | .5468       | .5894       | .6380       | .6960     | .7592    | .8358    | .9272  |
| 23854.0  | 22421.1   | 21015.8     | 19638.3     | 18288.7     | 16967.0     | 15673.4     | 14408.2     | 13171.6   | 11964.0  | 10785.6  |        |
| 2.04E-13   | 8.27E-09  | 5.45E-06    | 6.34E-04    | 1.91E-02    | 1.55E-01    | 2.49E-01    | 1.90E-04    | 1.20E-01  | 2.93E-02 | 1.35E-02 |        |
| 3.7747   | 2.0514    | 1.8078      | 1.6741      | 1.5834      | 1.5148      | 1.4629      | 1.8640      | 1.3630    | 1.2982   | 1.3170   |        |
| 1.12E-04   | 7.88E-02  | 1.29E+01    | 1.62E-01    | 1.86E-01    | 2.04E-01    | 2.17E-01    | 1.16E-01    | 2.43E-01  | 2.58E-01 | 2.54E-01 |        |
| ( 7.06E-14)( 1.17E-03)                               | 1.71E+00  | 2.56E+02    | 8.15E+03    | 6.38E+04    | 9.16E+04    | ( 1.56E+01) | 3.27E+04    | 6.77E+03  | 2.20E+03 |          |        |
| 5.74E-07*  | 7.61E-04* | 1.62E+00*   | 2.54E+02*   | 8.15E+03    | 6.40E+04    | 9.15E+04    | 1.02E+01*   | 3.26E+04  | 6.86E+03 | 2.15E+03 |        |
| 10   | .3953     | .4190       | .4453       | .4744       | .5068       | .5432       | .5842       | .6309     | .6843    | .7459    | .8178  |
| 25296.8  | 23864.0   | 22458.7     | 21081.2     | 19731.6     | 18409.9     | 17116.3     | 15851.1     | 14614.5   | 13406.8  | 12228.5  |        |
| 5.36E-14   | 6.22E-14  | 3.77E-08    | 1.68E-05    | 1.43E-03    | 3.25E-02    | 1.98E-01    | 2.06E-01    | 1.02E-02  | 8.96E-02 | 5.92E-02 |        |
| 1.5997   | 14.5540   | 2.0733      | 1.8205      | 1.6846      | 1.5934      | 1.5251      | 1.4753      | 1.3519    | 1.3774   | 1.3171   |        |
| 1.81E-01   | 0.00E+00  | 7.50E-02    | 1.26E-01    | 1.60E-01    | 1.83E-01    | 2.01E-01    | 2.14E-01    | 2.45E-01  | 2.39E-01 | 2.54E-01 |        |
| ( 5.79E-08)( 0.00E+00)( 4.86E-03)                    | 5.11E+00  | 5.67E+02    | 1.38E+04    | 8.11E+04    | 7.60E+04    | 3.90E+03    | 2.50E+04    | 1.41E+04  |          |          |        |
| 4.86E-08*  | 1.31E-05* | 2.96E-03*   | 4.81E+00*   | 5.61E+02*   | 1.38E+04    | 8.13E+04    | 7.59E+04    | 3.99E+03  | 2.48E+04 | 1.42E+04 |        |
| 11   | .3744     | .3956       | .4189       | .4446       | .4729       | .5045       | .5397       | .5792     | .6239    | .6748    | .7330  |
| 26710.0  | 25277.1   | 23871.9     | 22494.4     | 21144.7     | 19823.1     | 18529.5     | 17264.3     | 16027.7   | 14820.0  | 13641.7  |        |
| 1.70E-15   | 3.22E-14  | 2.97E-13    | 1.26E-07    | 4.28E-05    | 2.84E-03    | 5.04E-02    | 2.34E-01    | 1.52E-01  | 3.88E-02 | 5.15E-02 |        |
| 1.0771   | 2.8846    | 14.6460     | 2.0949      | 1.8336      | 1.6953      | 1.6037      | 1.5357      | 1.4895    | 1.3934   | 1.3953   |        |
| 3.01E-01   | 6.46E-03  | 0.00E+00    | 7.13E-02    | 1.23E-01    | 1.57E-01    | 1.80E-01    | 1.98E-01    | 2.10E-01  | 2.35E-01 | 2.35E-01 |        |
| 5.95E-09( 4.39E-11)( 0.00E+00)( 1.48E-02)            | 1.26E-01  | 1.25E+01    | 1.10E+03    | 2.11E+04    | 9.57E+04    | 5.59E+04    | 1.41E+04    | 1.46E+04  |          |          |        |
| 5.75E-09*  | 4.35E-08* | 6.01E-05*   | 8.36E-03*   | 1.17E+01*   | 1.09E+03*   | 2.12E+04    | 9.58E+04    | 5.58E+04  | 1.43E+04 | 1.44E+04 |        |
| 12   | .3560     | .3751       | .3960       | .4188       | .4439       | .4716       | .5022       | .5363     | .5744    | .6172    | .6656  |
| 28093.2  | 26660.3   | 25255.1     | 23877.6     | 22528.0     | 21206.3     | 19912.7     | 18647.5     | 17410.9   | 16203.2  | 15024.9  |        |
| 4.85E-14   | 1.61E-14  | 1.99E-15    | 5.12E-14    | 3.44E-07    | 9.49E-05    | 5.10E-03    | 7.29E-02    | 2.60E-01  | 9.69E-02 | 7.25E-02 |        |
| 1.2610   | 1.8337    | -14.2460    | -58.5080    | 2.1151      | 1.8470      | 1.7063      | 1.6143      | 1.5467    | 1.5069   | 1.4139   |        |
| 2.66E-01   | 1.23E-01  | 0.00E+00    | 0.00E+00    | 6.80E-02    | 1.20E-01    | 1.54E-01    | 1.78E-01    | 1.95E-01  | 2.06E-01 | 2.30E-01 |        |
| 1.55E-07( 9.40E-09)( 0.00E+00)( 0.00E+00)( 3.69E-02) | 2.65E+01  | 1.94E+03    | 3.02E+04    | 1.94E+03    | 3.02E+04    | 1.06E+05    | 3.54E+04    | 2.63E+04  |          |          |        |
| 1.52E-07*  | 1.40E-08* | 1.45E-06*   | 2.44E-04*   | 1.94E-02*   | 2.47E+01*   | 1.91E+03*   | 3.02E+04    | 1.06E+05  | 3.52E+04 | 2.64E+04 |        |
| 13   | .3396     | .3570       | .3758       | .3963       | .4187       | .4433       | .4702       | .5000     | .5329    | .5696    | .6106  |
| 29446.3  | 28013.4   | 26608.2     | 25230.7     | 23881.0     | 22559.3     | 21265.8     | 20000.6     | 18764.0   | 17556.3  | 16377.9  |        |
| 2.38E-14   | 3.88E-14  | 7.27E-14    | 7.16E-13    | 1.17E-11    | 8.14E-07    | 1.90E-04    | 8.50E-03    | 9.94E-02  | 2.73E-01 | 5.03E-02 |        |
| 1.2347   | 1.1724    | .6158       | -.5336      | -5.3319     | 2.1350      | 1.8608      | 1.7175      | 1.6252    | 1.5583   | 1.5307   |        |
| 2.72E-01   | 2.85E-01  | 3.13E-01    | 6.51E-02    | 6.49E-16    | 6.49E-02    | 1.17E-01    | 1.51E-01    | 1.75E-01  | 1.92E-01 | 2.00E-01 |        |
| 9.12E-08   | 1.40E-07  | ( 2.72E-07) | ( 9.87E-08) | ( 1.36E-34) | ( 7.97E-02) | 5.07E+01    | 3.15E+03    | 4.06E+04  | 1.11E+05 | 1.78E+04 |        |
| 8.97E-08*  | 1.29E-07* | 4.31E-07*   | 1.38E-05*   | 8.62E-04*   | 3.89E-02*   | 4.70E+01*   | 3.11E+03*   | 4.06E+04  | 1.11E+05 | 1.77E+04 |        |
| 14   | .3250     | .3409       | .3580       | .3766       | .3968       | .4187       | .4427       | .4690     | .4978    | .5297    | .5650  |
| 30768.9  | 29336.0   | 27930.7     | 26553.2     | 25203.6     | 23881.9     | 22588.4     | 21323.1     | 20086.5   | 18878.9  | 17700.5  |        |
| 1.39E-15   | 1.03E-13  | 2.00E-13    | 1.44E-12    | 7.24E-12    | 8.94E-11    | 1.73E-06    | 3.49E-04    | 1.33E-02  | 1.29E-01 | 2.73E-01 |        |
| 1.5158   | 1.2370    | 1.0240      | -.8833      | .1627       | -2.4150     | 2.1558      | 1.8749      | 1.7290    | 1.6365   | 1.5706   |        |
| 2.03E-01   | 2.72E-01  | 3.08E-01    | 3.21E-01    | 2.24E-01    | 2.94E-05    | 6.17E-02    | 1.14E-01    | 1.48E-01  | 1.72E-01 | 1.89E-01 |        |
| ( 3.40E-09)  | 3.89E-07  | 8.41E-07    | ( 5.61E-06) | ( 1.18E-05) | ( 2.13E-12) | ( 1.53E-01) | 8.93E+01    | 4.82E+03  | 5.20E+04 | 1.09E+05 |        |
| 3.88E-09*  | 3.72E-07* | 8.16E-07*   | 6.41E-06*   | 7.56E-05*   | 2.45E-03*   | 6.82E-02*   | 8.22E+01*   | 4.75E+03  | 5.20E+04 | 1.10E+05 |        |
| 15   | .3119     | .3265       | .3422       | .3591       | .3774       | .3972       | .4188       | .4422     | .4678    | .4958    | .5265  |
| 32060.7  | 30627.8   | 29222.6     | 27845.1     | 26495.4     | 25173.7     | 23880.2     | 22615.0     | 21378.4   | 20170.7  | 18992.4  |        |
| 2.13E-14   | 1.90E-14  | 2.58E-13    | 1.53E-12    | 5.93E-12    | 3.04E-11    | 3.62E-10    | 3.37E-06    | 6.04E-04  | 1.99E-02 | 1.61E-01 |        |
| 1.3336   | 1.0659    | 1.0815      | 1.0411      | .8420       | .3094       | -1.4002     | 2.1759      | 1.8893    | 1.7408   | 1.6482   |        |
| 2.50E-01   | 3.03E-01  | 3.00E-01    | 3.06E-01    | 3.22E-01    | 2.60E-01    | 4.14E-03    | 5.87E-02    | 1.11E-01  | 1.45E-01 | 1.69E-01 |        |
| 8.85E-08   | 1.01E-07  | 1.18E-06    | 6.28E-06    | ( 2.32E-05) | ( 6.63E-05) | ( 1.71E-07) | ( 2.72E-01) | 1.47E+02  | 7.00E+03 | 6.36E+04 |        |
| 9.02E-08*  | 9.98E-08* | 1.14E-06*   | 6.10E-06*   | 2.77E-05*   | 2.67E-04*   | 5.91E-03*   | 1.10E-01*   | 1.35E+02* | 6.90E+03 | 6.36E+04 |        |

Table 3. Radiative transition parameters for  $N_2$   $B\ ^3\Pi_g - A\ ^3\Sigma_u^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| $v'\backslash v''$ | 11   | 12  | 13   | 14   | 15  | 16   | 17  | 18  | 19  | 20  | 21                               |
|--------------------|--|---|--|--|---|--|---|---|---|---|----------------------------------|
| 8                  | 1.2248<br>8164.6<br>3.35E-02<br>1.2061<br>2.78E-01<br>2.86E+03<br>2.89E+03     | 1.4192<br>7046.4<br>9.35E-03<br>1.1146<br>2.95E-01<br>7.13E+01<br>7.71E+01* | 1.6781<br>4903.9<br>3.29E-02<br>1.1554<br>2.88E-01<br>3.16E+02<br>3.09E+02*    | 2.0392<br>3881.2<br>4.89E-02<br>1.1309<br>2.92E-01<br>6.52E+02<br>6.47E+02 | 2.5765<br>2892.1<br>5.16E-02<br>1.1101<br>2.96E-01<br>4.95E+02<br>4.93E+02  | 3.4576<br>1937.9<br>4.52E-02<br>1.0916<br>2.99E-01<br>2.21E+02<br>2.21E+02 | 5.1601<br>1019.8<br>3.53E-02<br>1.0747<br>3.01E-01<br>5.95E+01<br>5.96E+01  | 9.8056<br>139.2<br>2.55E-02<br>1.0592<br>3.04E-01<br>6.89E+00<br>6.91E+00   | 71.8231<br>-702.3<br>1.75E-02<br>1.0447<br>3.06E-01<br>1.29E-02<br>1.29E-02 | -14.2399<br>-1502.9<br>1.16E-02<br>1.0312<br>3.07E-01<br>-2.30E+00<br>-1.51E+01 | -6.6539<br>-1502.9<br>-Continued |
| 9                  | 1.0377<br>9637.0<br>6.59E-02<br>1.2585<br>2.67E-01<br>8.51E+03<br>8.47E+03     | 1.1739<br>8518.9<br>5.32E-02<br>1.2208<br>2.75E-01<br>5.04E+03<br>5.06E+03  | 1.3456<br>7431.7<br>1.34E-02<br>1.1803<br>2.43E-01<br>( 5.37E+00)<br>4.45E+00* | 1.5683<br>6376.3<br>1.73E-04<br>1.3620<br>2.85E-01<br>3.37E+02<br>3.31E+02 | 1.8679<br>5353.6<br>1.34E-02<br>1.7288<br>2.90E-01<br>4.56E+02<br>4.53E+02  | 2.2912<br>4364.6<br>3.22E-02<br>1.1435<br>2.90E-01<br>3.01E+02<br>3.00E+02 | 2.9322<br>3410.4<br>4.34E-02<br>1.1214<br>2.94E-01<br>1.24E+02<br>1.24E+02  | 4.0124<br>2492.3<br>4.49E-02<br>1.1024<br>2.97E-01<br>3.03E+01<br>3.04E+01  | 6.2048<br>1611.7<br>3.98E-02<br>1.0853<br>3.00E-01<br>2.70E+00<br>2.71E+00  | 12.9839<br>770.2<br>3.20E-02<br>1.0697<br>3.02E-01<br>-2.54E-04<br>-2.55E-04    | -328.5799<br>-30.4<br>-Continued |
| 10                 | .9025<br>11079.9<br>2.18E-04<br>1.5735<br>1.88E-01<br>( 2.13E+01)<br>1.69E+01* | 1.0038<br>9961.7<br>4.15E-02<br>1.2741<br>2.64E-01<br>5.77E+03<br>5.71E+03  | 1.1268<br>8874.6<br>3.11E-02<br>1.2344<br>2.72E-01<br>6.27E+03<br>6.27E+03     | 1.2789<br>7819.2<br>4.23E-03<br>1.1998<br>2.79E-01<br>2.35E+03<br>2.38E+03 | 1.4713<br>6796.5<br>1.81E-03<br>1.5153<br>2.89E-01<br>5.47E+01<br>5.17E+01* | 1.7219<br>5807.5<br>1.52E-02<br>1.2152<br>2.76E-01<br>2.24E+02<br>2.33E+02 | 2.0605<br>4853.3<br>3.00E-02<br>1.5188<br>2.87E-01<br>2.92E+02<br>2.87E+02  | 2.5412<br>3935.2<br>3.84E-02<br>1.1337<br>2.95E-01<br>3.15E+02<br>3.13E+02  | 3.2758<br>3054.6<br>3.95E-02<br>1.1138<br>2.98E-01<br>1.93E+02<br>1.92E+02  | 4.5186<br>2213.1<br>3.57E-02<br>1.0963<br>3.01E-01<br>7.71E+01<br>7.70E+01      | 7.0798<br>1412.5<br>-Continued   |
| 11                 | .8004<br>12493.1<br>7.96E-02<br>1.3320<br>2.50E-01<br>1.97E+04<br>1.97E+04     | .8791<br>11374.9<br>6.40E-03<br>1.2510<br>2.69E-01<br>1.38E+03<br>1.43E+03* | .9720<br>10287.7<br>1.68E-02<br>1.2971<br>2.58E-01<br>2.47E+03<br>2.42E+03     | 1.0831<br>9232.4<br>5.13E-02<br>1.2489<br>2.69E-01<br>5.92E+03<br>5.89E+03 | 1.2181<br>8209.7<br>4.43E-02<br>1.2151<br>2.76E-01<br>3.79E+03<br>3.80E+03  | 1.3849<br>7220.6<br>1.67E-02<br>1.1821<br>2.83E-01<br>1.02E+03<br>1.04E+03 | 1.5958<br>6266.4<br>8.82E-04<br>1.1076<br>2.96E-01<br>3.84E+01<br>4.19E+01* | 1.8697<br>5348.3<br>3.50E-03<br>1.1847<br>2.82E-01<br>8.64E+01<br>4.19E+01* | 2.2383<br>4467.7<br>1.55E-02<br>1.1477<br>2.89E-01<br>2.35E+02<br>8.31E+01  | 2.7577<br>3626.2<br>2.72E-02<br>1.1257<br>2.93E-01<br>2.26E+02<br>2.31E+02      | 3.5390<br>2825.6<br>-Continued   |
| 12                 | .7207<br>13876.3<br>1.95E-02<br>1.4236<br>2.27E-01<br>5.45E+03<br>5.34E+03     | .7838<br>12758.1<br>8.29E-02<br>1.3461<br>2.47E-01<br>5.48E+03<br>5.56E+03  | .8568<br>11671.0<br>2.51E-02<br>1.2885<br>2.58E-01<br>2.87E+02<br>2.69E+02*    | .9420<br>10615.6<br>2.03E-03<br>1.3684<br>2.76E-01<br>4.15E+03<br>4.11E+03 | 1.0424<br>9592.9<br>4.43E-02<br>1.2151<br>2.76E-01<br>4.49E+03<br>4.49E+03  | 1.1623<br>8603.9<br>1.67E-02<br>1.1821<br>2.83E-01<br>4.49E+03<br>2.14E+03 | 1.3072<br>7649.7<br>8.82E-04<br>1.1076<br>2.79E-01<br>2.12E+03<br>2.14E+03  | 1.4855<br>6731.5<br>3.50E-03<br>1.1847<br>2.82E-01<br>4.35E+02<br>4.45E+02* | 1.7091<br>5851.0<br>1.55E-02<br>1.1477<br>2.89E-01<br>1.79E+00<br>9.13E+01* | 1.9962<br>5009.5<br>2.72E-02<br>1.1257<br>2.93E-01<br>9.44E+01<br>1.36E+02      | 2.3759<br>4208.9<br>-Continued   |
| 13                 | .6566<br>15229.4<br>9.99E-02<br>1.4302<br>2.26E-01<br>3.64E+04<br>3.65E+04     | .7087<br>14111.2<br>2.15E-03<br>1.5231<br>2.02E-01<br>4.97E+02<br>4.66E+02* | .7678<br>13024.0<br>6.96E-02<br>1.3610<br>2.43E-01<br>1.84E+04<br>1.83E+04     | .8355<br>11968.6<br>4.58E-02<br>1.3077<br>2.56E-01<br>1.04E+04<br>1.05E+04 | .9136<br>10945.9<br>1.54E-03<br>1.1828<br>2.83E-01<br>3.28E+02<br>3.53E+02* | 1.0043<br>9956.9<br>1.38E-02<br>1.2915<br>2.65E-01<br>2.66E+03<br>1.82E+03 | 1.1108<br>9002.7<br>3.77E-02<br>1.2468<br>2.73E-01<br>2.12E+03<br>4.03E+03  | 1.2369<br>8084.6<br>3.71E-02<br>1.2167<br>2.79E-01<br>2.65E-01<br>4.03E+03  | 1.3881<br>7204.0<br>1.96E-02<br>1.1903<br>2.81E-01<br>1.18E+03<br>1.19E+03  | 1.5717<br>6362.5<br>4.40E-03<br>1.1616<br>2.87E-01<br>1.89E+02<br>1.96E+02*     | 1.7979<br>5561.9<br>-Continued   |
| 14                 | .6042<br>16552.0<br>1.76E-02<br>1.5740<br>1.88E-01<br>5.72E+03<br>5.68E+03     | .6479<br>15433.8<br>1.14E-01<br>1.4455<br>2.22E-01<br>8.26E+02<br>8.82E+02* | .6970<br>14346.6<br>1.96E-03<br>1.2663<br>2.39E-01<br>1.26E+04<br>1.24E+04     | .7524<br>13291.2<br>4.64E-02<br>1.3782<br>2.52E-01<br>1.40E+04<br>1.40E+04 | .8151<br>12268.5<br>5.90E-02<br>1.3235<br>2.66E-01<br>2.67E+03<br>2.72E+03  | .8866<br>11279.5<br>1.30E-02<br>1.2643<br>2.66E-01<br>2.36E+02<br>2.72E+03 | .9685<br>10325.3<br>1.82E-03<br>1.3695<br>2.41E-01<br>2.64E+03<br>2.61E+03  | 1.0630<br>9407.2<br>2.23E-02<br>1.2679<br>2.65E-01<br>2.64E+03<br>2.50E+02* | 1.1728<br>8526.6<br>2.77E-02<br>1.2343<br>2.72E-01<br>2.78E-01<br>3.23E+03  | 1.3012<br>7685.1<br>1.28E-02<br>1.2088<br>2.82E-01<br>1.96E+03<br>1.97E+03      | 1.4525<br>6884.5<br>-Continued   |
| 15                 | .5604<br>17843.8<br>2.59E-01<br>1.5837<br>1.86E-01<br>1.03E+05<br>1.03E+05     | .5979<br>16725.6<br>1.67E-03<br>1.7615<br>1.40E-01<br>3.12E+02<br>3.00E+02* | .6394<br>15638.4<br>1.12E-01<br>1.4611<br>2.18E-01<br>4.10E+04<br>4.10E+04     | .6857<br>14583.1<br>1.57E-02<br>1.3682<br>2.33E-01<br>5.75E+03<br>5.99E+03 | .7374<br>13560.4<br>2.23E-02<br>1.4015<br>2.41E-01<br>6.10E+03<br>1.48E+04  | .7955<br>12571.3<br>5.97E-02<br>1.3389<br>2.48E-01<br>4.05E+03<br>1.48E+04 | .8608<br>11617.1<br>2.95E-02<br>1.2896<br>2.60E-01<br>6.33E+03<br>6.38E+03  | .9347<br>10699.0<br>1.11E-03<br>1.1472<br>2.89E-01<br>2.57E-01<br>2.50E+02* | 1.0185<br>9818.4<br>7.78E-03<br>1.3044<br>2.57E-01<br>2.68E-01<br>9.60E+02* | 1.1140<br>8976.9<br>2.44E-02<br>1.2557<br>1.2283<br>2.74E-01<br>2.37E+03        | 1.2230<br>8176.3<br>-Continued   |

Table 3. Radiative transition parameters for  $N_2$   $B\ ^3\Pi_g - A\ ^3\Sigma_u^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| $V'\backslash V''$ | 0           | 1           | 2           | 3           | 4           | 5           | 6           | 7           | 8           | 9           | 10      |
|--------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------|
| 16                 | .3001       | .3136       | .3280       | .3436       | .3603       | .3783       | .3978       | .4188       | .4417       | .4666       | .4938   |
|                    | 33321.5     | 31888.6     | 30483.4     | 29105.9     | 27756.2     | 26434.5     | 25141.0     | 23875.8     | 22639.2     | 21431.5     | 20253.1 |
| 7.87E-15           | 3.69E-15    | 1.82E-13    | 9.07E-13    | 4.86E-12    | 1.89E-11    | 1.33E-10    | 1.10E-09    | 6.17E-06    | 9.92E-04    | 2.85E-02    |         |
| 1.3359             | 1.9280      | 1.0855      | 1.0262      | .9992       | .7982       | .5433       | .8678       | 2.1957      | 1.9038      | 1.7529      |         |
| 2.49E-01           | 1.03E-01    | 3.00E-01    | 3.08E-01    | 3.11E-01    | 3.23E-01    | 3.04E-01    | 2.64E-02    | 5.59E-02    | 1.08E-01    | 1.42E-01    |         |
| 3.66E-08           | ( 2.55E-09) | 9.38E-07    | 4.30E-06    | 2.04E-05    | ( 7.36E-05) | ( 3.95E-04) | ( 2.12E-05) | ( 4.53E-01) | 2.30E+02    | 9.74E+03    |         |
| 3.75E-08*          | 4.19E-09*   | 9.17E-07*   | 4.23E-06*   | 2.01E-05*   | 9.30E-05*   | 8.84E-04*   | 1.27E-02*   | 1.65E-01*   | 2.09E+02*   | 9.59E+03    |         |
| 17                 | .2894       | .3020       | .3153       | .3296       | .3450       | .3615       | .3792       | .3983       | .4190       | .4413       | .4655   |
|                    | 34550.8     | 33117.9     | 31712.7     | 30335.2     | 28985.6     | 27663.9     | 26370.3     | 25105.1     | 23868.5     | 22660.8     | 21482.5 |
| 2.81E-15           | 2.57E-15    | 5.85E-14    | 3.72E-13    | 2.66E-12    | 1.73E-11    | 5.59E-11    | 4.15E-10    | 2.57E-09    | 1.07E-05    | 1.56E-03    |         |
| 1.2393             | 1.8350      | 1.0224      | .9826       | .9897       | 1.0157      | .7801       | .6605       | .6298       | 2.2150      | 1.9185      |         |
| 2.71E-01           | 1.23E-01    | 3.09E-01    | 3.13E-01    | 3.12E-01    | 3.09E-01    | 3.22E-01    | 3.17E-01    | 5.12E-02    | 5.32E-02    | 1.05E-01    |         |
| 1.72E-08           | ( 2.86E-09) | 3.60E-07    | 2.06E-06    | 1.28E-05    | 7.08E-05    | ( 2.16E-04) | ( 1.34E-03) | ( 1.86E-04) | ( 7.16E-01) | ( 3.44E+02) |         |
| 1.69E-08*          | 4.35E-09*   | 3.58E-07*   | 2.07E-06*   | 1.27E-05*   | 6.90E-05*   | 2.81E-04*   | 2.35E-03*   | 2.40E-02*   | 2.34E-01*   | 3.11E+02*   |         |
| 18                 | .2797       | .2914       | .3039       | .3171       | .3313       | .3465       | .3627       | .3802       | .3989       | .4191       | .4409   |
|                    | 35748.4     | 34315.5     | 32910.3     | 31532.8     | 30183.1     | 28861.4     | 27567.9     | 26302.7     | 25066.1     | 23858.4     | 22680.0 |
| 2.15E-14           | 8.68E-15    | 3.34E-15    | 1.01E-13    | 1.21E-12    | 8.52E-12    | 3.91E-11    | 1.27E-10    | 1.09E-09    | 4.70E-09    | 1.79E-05    |         |
| 1.2759             | 1.2126      | .5808       | .8938       | .9714       | .9964       | .9679       | .7334       | .7539       | .5988       | 2.2337      |         |
| 2.63E-01           | 2.77E-01    | 3.09E-01    | 3.20E-01    | 3.14E-01    | 3.12E-01    | 3.15E-01    | 3.21E-01    | 3.22E-01    | 5.55E-02    | 5.07E-02    |         |
| 1.38E-07           | 5.45E-08    | ( 2.30E-08) | 6.55E-07    | 6.67E-06    | 4.03E-05    | 1.64E-04    | ( 4.85E-04) | ( 3.59E-03) | ( 3.98E-04) | ( 1.09E+00) |         |
| 1.37E-07*          | 5.20E-08*   | 3.53E-08*   | 6.85E-07*   | 6.67E-06*   | 3.95E-05*   | 1.64E-04*   | 6.73E-04*   | 5.37E-03*   | 4.02E-02*   | 3.19E-01*   |         |
| 19                 | .2709       | .2818       | .2935       | .3058       | .3190       | .3330       | .3480       | .3641       | .3812       | .3996       | .4194   |
|                    | 36913.8     | 35480.9     | 34075.6     | 32698.1     | 31348.5     | 30026.8     | 28733.3     | 27468.0     | 26231.4     | 25023.8     | 23845.4 |
| 1.58E-14           | 2.85E-14    | 2.32E-15    | 1.49E-14    | 4.32E-13    | 2.68E-12    | 1.81E-11    | 7.74E-11    | 2.45E-10    | 2.48E-09    | 6.94E-09    |         |
| 1.2783             | 1.3289      | 1.6956      | .6887       | .9482       | .9069       | .9691       | .9351       | .6760       | .8372       | .7560       |         |
| 2.63E-01           | 2.51E-01    | 1.57E-01    | 3.19E-01    | 3.16E-01    | 3.19E-01    | 3.14E-01    | 3.17E-01    | 3.18E-01    | 3.22E-01    | 3.65E-02    |         |
| 1.11E-07           | 1.62E-07    | ( 4.56E-09) | ( 1.08E-07) | 2.70E-06    | 1.50E-05    | 8.59E-05    | 3.27E-04    | ( 9.09E-04) | ( 8.17E-03) | ( 2.54E-04) |         |
| 1.11E-07*          | 1.59E-07*   | 7.23E-09*   | 1.35E-07*   | 2.70E-06*   | 1.56E-05*   | 8.47E-05*   | 3.34E-04*   | 1.38E-03*   | 1.08E-02*   | 6.06E-02*   |         |
| 20                 | .2628       | .2731       | .2840       | .2956       | .3079       | .3209       | .3348       | .3496       | .3654       | .3823       | .4003   |
|                    | 38046.5     | 36613.6     | 35208.4     | 33830.9     | 32481.2     | 31159.6     | 29866.0     | 28600.8     | 27364.2     | 26156.5     | 24978.2 |
| 4.34E-16           | 7.75E-15    | 4.45E-15    | 4.00E-16    | 8.14E-14    | 6.57E-13    | 5.59E-12    | 3.13E-11    | 1.28E-10    | 4.26E-10    | 5.19E-09    |         |
| 1.2702             | 1.3785      | 1.3429      | -.3399      | .8656       | .8393       | .9208       | .9430       | .8916       | .6251       | .9261       |         |
| 2.64E-01           | 2.39E-01    | 2.47E-01    | 1.00E-01    | 3.21E-01    | 3.22E-01    | 3.18E-01    | 3.17E-01    | 3.20E-01    | 3.14E-01    | 3.18E-01    |         |
| 3.39E-09           | 4.39E-08    | 2.41E-08    | ( 3.15E-10) | 5.84E-07    | 4.18E-06    | 3.06E-05    | 1.49E-04    | 5.43E-04    | ( 1.52E-03) | ( 1.66E-02) |         |
| 3.38E-09*          | 4.35E-08*   | 2.64E-08*   | 7.52E-09*   | 6.01E-07*   | 4.49E-06*   | 3.08E-05*   | 1.47E-04*   | 5.73E-04*   | 2.54E-03*   | 1.96E-02*   |         |
| 21                 | .2555       | .2652       | .2754       | .2863       | .2978       | .3100       | .3229       | .3367       | .3513       | .3669       | .3835   |
|                    | 39146.2     | 37713.3     | 36308.0     | 34930.5     | 33580.9     | 32259.2     | 30965.7     | 29700.4     | 28463.8     | 27256.2     | 26077.8 |
| 7.68E-15           | 5.12E-15    | 1.38E-15    | 7.89E-16    | 9.58E-17    | 7.83E-14    | 7.45E-13    | 7.07E-12    | 4.30E-11    | 1.71E-10    | 6.13E-10    |         |
| 1.2794             | 1.2644      | 1.1271      | 1.3948      | 5.4900      | .8176       | .7645       | .8653       | .9074       | .8234       | .5337       |         |
| 2.62E-01           | 2.66E-01    | 2.93E-01    | 2.35E-01    | 8.15E-10    | 3.23E-01    | 3.22E-01    | 3.21E-01    | 3.19E-01    | 3.22E-01    | 3.03E-01    |         |
| 6.43E-08           | 3.93E-08    | 1.15E-08    | ( 3.75E-09) | ( 4.88E-27) | 5.54E-07    | 4.65E-06    | 3.88E-05    | 2.05E-04    | ( 7.31E-04) | ( 2.02E-03) |         |
| 6.42E-08*          | 3.91E-08*   | 1.23E-08*   | 5.38E-09*   | 4.02E-10*   | 5.37E-07*   | 5.14E-06*   | 3.95E-05*   | 2.03E-04*   | 8.22E-04*   | 4.02E-03*   |         |

Table 3. Radiative transition parameters for  $N_2$   $B\ ^3\Pi_g - A\ ^3\Sigma_u^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}, \bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued.

| $V'\backslash V''$ | 11          | 12          | 13          | 14       | 15        | 16          | 17        | 18          | 19        | 20          | 21      |
|--------------------|-------------|-------------|-------------|----------|-----------|-------------|-----------|-------------|-----------|-------------|---------|
| 16                 | .5234       | .5560       | .5917       | .6312    | .6747     | .7230       | .7765     | .8361       | .9026     | .9768       | 1.0596  |
|                    | 19104.6     | 17986.4     | 16899.2     | 15843.8  | 14821.1   | 13832.1     | 12877.9   | 11959.8     | 11079.2   | 10237.7     | 9437.1  |
| 1.93E-01           | 2.33E-01    | 2.22E-03    | 9.54E-02    | 3.65E-02 | 5.30E-03  | 4.84E-02    | 4.28E-02  | 1.03E-02    | 3.50E-04  | 1.15E-02    |         |
| 1.6604             | 1.5979      | 1.2989      | 1.4782      | 1.3988   | 1.4502    | 1.3550      | 1.3079    | 1.2495      | 1.5266    | 1.2878      |         |
| 1.66E-01           | 1.82E-01    | 2.58E-01    | 2.13E-01    | 2.34E-01 | 2.21E-01  | 2.44E-01    | 2.56E-01  | 2.69E-01    | 2.01E-01  | 2.60E-01    |         |
| 7.49E+04           | 9.08E+04    | 1.44E+03    | 3.49E+04    | 1.32E+04 | 1.38E+03  | 1.25E+04    | 9.70E+03  | 2.05E+03    | 3.06E+01  | 1.32E+03    |         |
| 7.49E+04           | 9.11E+04    | 1.48E+03*   | 3.48E+04    | 1.33E+04 | 1.32E+03* | 1.24E+04    | 9.72E+03  | 2.09E+03    | 2.80E+01* | 1.31E+03    |         |
| 17                 | .4918       | .5204       | .5516       | .5857    | .6230     | .6639       | .7089     | .7582       | .8124     | .8721       | .9375   |
|                    | 20333.9     | 19215.7     | 18128.6     | 17073.2  | 16050.5   | 15061.5     | 14107.3   | 13189.1     | 12308.6   | 11467.1     | 10666.5 |
| 3.94E-02           | 2.24E-01    | 1.98E-01    | 1.64E-02    | 6.99E-02 | 5.65E-02  | 3.73E-05    | 3.04E-02  | 4.71E-02    | 2.38E-02  | 2.52E-03    |         |
| 1.7653             | 1.6731      | 1.6134      | 1.4512      | 1.4983   | 1.4201    | .5731       | 1.3737    | 1.3246      | 1.2786    | 1.1778      |         |
| 1.39E-01           | 1.62E-01    | 1.78E-01    | 2.20E-01    | 2.08E-01 | 2.28E-01  | 3.08E-01    | 2.40E-01  | 2.52E-01    | 2.63E-01  | 2.84E-01    |         |
| 1.31E+04           | 8.51E+04    | 7.55E+04    | 8.01E+03    | 2.53E+04 | 2.04E+04  | ( 2.01E+01) | 8.12E+03  | 1.13E+04    | 5.01E+03  | 4.99E+02    |         |
| 1.29E+04           | 8.52E+04    | 7.58E+04    | 8.00E+03    | 2.52E+04 | 2.05E+04  | 5.28E+01*   | 8.00E+03  | 1.12E+04    | 5.04E+03  | 5.21E+02*   |         |
| 18                 | .4644       | .4899       | .5174       | .5473    | .5798     | .6150       | .6534     | .6951       | .7404     | .7896       | .8429   |
|                    | 21531.5     | 20413.3     | 19326.1     | 18270.8  | 17248.1   | 16259.0     | 15304.8   | 14386.7     | 13506.1   | 12664.6     | 11864.0 |
| 2.38E-03           | 5.29E-02    | 2.53E-01    | 1.57E-01    | 3.94E-02 | 4.19E-02  | 6.89E-02    | 6.43E-03  | 1.27E-02    | 4.09E-02  | 3.47E-02    |         |
| 1.9332             | 1.7781      | 1.6863      | 1.6309      | 1.4939   | 1.5245    | 1.4395      | 1.3475    | 1.3995      | 1.3413    | 1.2990      |         |
| 1.02E-01           | 1.36E-01    | 1.59E-01    | 1.73E-01    | 2.09E-01 | 2.01E-01  | 2.23E-01    | 2.46E-01  | 2.33E-01    | 2.48E-01  | 2.58E-01    |         |
| ( 4.96E+02)        | 1.70E+04    | 9.36E+04    | 5.82E+04    | 1.79E+04 | 1.48E+04  | 2.49E+04    | 2.36E+03  | 3.46E+03    | 1.03E+04  | 7.80E+03    |         |
| 4.46E+02*          | 1.67E+04    | 9.38E+04    | 5.86E+04    | 1.79E+04 | 1.47E+04  | 2.50E+04    | 2.44E+03* | 3.36E+03    | 1.02E+04  | 7.79E+03    |         |
| 19                 | .4406       | .4634       | .4880       | .5145    | .5431     | .5739       | .6072     | .6430       | .6816     | .7231       | .7675   |
|                    | 22696.9     | 21578.7     | 20491.5     | 19436.1  | 18413.4   | 17424.4     | 16470.2   | 15552.1     | 14671.5   | 13830.0     | 13029.4 |
| 2.91E-05           | 3.52E-03    | 6.93E-02    | 2.77E-01    | 1.14E-01 | 6.56E-02  | 1.80E-02    | 7.01E-02  | 2.04E-02    | 1.82E-03  | 2.73E-02    |         |
| 2.2510             | 1.9478      | 1.7912      | 1.7002      | 1.6514   | 1.5204    | 1.5669      | 1.4594    | 1.3910      | 1.4652    | 1.3593      |         |
| 4.85E-02           | 9.86E-02    | 1.33E-01    | 1.56E-01    | 1.68E-01 | 2.02E-01  | 1.90E-01    | 2.18E-01  | 2.36E-01    | 2.17E-01  | 2.43E-01    |         |
| ( 1.62E+00)        | ( 6.96E+02) | 2.14E+04    | 9.96E+04    | 4.08E+04 | 2.88E+04  | 5.87E+03    | 2.54E+04  | 7.25E+03    | 4.57E+02  | 7.26E+03    |         |
| 4.29E-01*          | 6.22E+02*   | 2.11E+04    | 1.00E+05    | 4.12E+04 | 2.86E+04  | 5.84E+03    | 2.54E+04  | 7.36E+03    | 4.20E+02* | 7.13E+03    |         |
| 20                 | .4196       | .4403       | .4624       | .4862    | .5116     | .5389       | .5681     | .5993       | .6327     | .6683       | .7061   |
|                    | 23829.6     | 22711.4     | 21624.2     | 20568.9  | 19546.2   | 18557.1     | 17602.9   | 16684.8     | 15804.2   | 14962.7     | 14162.1 |
| 7.50E-09           | 4.62E-05    | 5.09E-03    | 8.85E-02    | 2.95E-01 | 7.40E-02  | 8.91E-02    | 3.27E-03  | 6.02E-02    | 3.56E-02  | 7.94E-04    |         |
| -1.3019            | 2.2669      | 1.9625      | 1.8048      | 1.7149   | 1.6772    | 1.5420      | 1.6887    | 1.4820      | 1.4176    | 1.2792      |         |
| 6.05E-03           | 4.65E-02    | 9.56E-02    | 1.30E-01    | 1.52E-01 | 1.61E-01  | 1.97E-01    | 1.58E-01  | 2.12E-01    | 2.29E-01  | 2.62E-01    |         |
| ( 7.53E-06)        | ( 2.37E+00) | ( 9.53E+02) | 2.64E+04    | 1.03E+05 | 2.50E+04  | 3.80E+04    | 7.72E+02  | 2.17E+04    | 1.27E+04  | ( 3.14E+02) |         |
| 8.09E-02*          | 5.79E-01*   | 8.47E+02*   | 2.60E+04    | 1.03E+05 | 2.53E+04  | 3.79E+04    | 7.62E+02* | 2.16E+04    | 1.28E+04  | 3.52E+02*   |         |
| 21                 | .4011       | .4200       | .4401       | .4615    | .4844     | .5087       | .5347     | .5623       | .5916     | .6226       | .6552   |
|                    | 24929.3     | 23811.1     | 22723.9     | 21668.5  | 20645.8   | 19656.8     | 18702.6   | 17784.5     | 16903.9   | 16062.4     | 15261.8 |
| 9.58E-09           | 5.78E-09    | 7.19E-05    | 7.21E-03    | 1.11E-01 | 5.05E-01  | 4.04E-02    | 1.04E-01  | 4.50E-04    | 4.25E-02  | 4.58E-02    |         |
| 1.0010             | -2.5718     | 2.2823      | 1.9774      | 1.8191   | 1.7307    | 1.7140      | 1.5613    | 1.0296      | 1.5099    | 1.4420      |         |
| 3.11E-01           | 1.16E-05    | 4.47E-02    | 9.26E-02    | 1.27E-01 | 1.48E-01  | 1.52E-01    | 1.91E-01  | 3.08E-01    | 2.05E-01  | 2.23E-01    |         |
| 2.91E-02*          | ( 2.13E-11) | ( 3.41E+00) | ( 1.28E+03) | 3.17E+04 | 1.03E+05  | 1.24E+04    | 4.36E+04  | ( 4.17E+02) | 1.50E+04  | 1.64E+04    |         |
| 3.16E-02*          | 9.80E-02*   | 7.73E-01*   | 1.13E+03*   | 3.12E+04 | 1.04E+05  | 1.27E+04    | 4.34E+04  | 4.79E+02*   | 1.49E+04  | 1.64E+04    |         |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 4. Radiative transition parameters for  $N_2 W^3\Delta_u - B^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu m$ ),  $\nu_{v'v''}$  ( $cm^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $s^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $s^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $V' \setminus V''$ | 0   | 1  | 2  | 3   | 4   | 5   | 6  | 7  | 8   | 9   | 10  |
|--------------------|---|--|--|---|---|---|--|--|---|---|---|
| 0                  | 136.1044<br>73.5<br>4.67E-01<br>1.2504<br>2.88E-01<br>3.11E-02<br>3.10E-02  | -6.1281<br>-1631.8<br>3.88E-01<br>1.2982<br>2.73E-01<br>-2.55E+02<br>-2.55E+02 | -3.0229<br>-3308.1<br>1.24E-01<br>1.95E-02<br>2.33E-01<br>-2.61E+02<br>-2.63E+02 | -2.0180<br>-4955.4<br>1.55E-03<br>1.4177<br>2.04E-01<br>-3.72E+01<br>-3.74E+01* | -1.5212<br>-6573.7<br>5.70E-05<br>1.4990<br>1.65E-01<br>-1.71E+00<br>-1.67E+00* | -1.2250<br>-8163.0<br>7.17E-07<br>1.6124<br>1.02E-01<br>(-1.38E-02)(-1.71E-13)(-8.94E-06)(-1.52E-11)(-6.92E-09) | -1.0285<br>-9723.2<br>2.83E-10<br>1.8164<br>1.45E-05<br>-1.04E-02*<br>-1.04E-02*   | -0.8886<br>-11254.3<br>6.25E-11<br>3.5359<br>1.84E-01<br>-2.05E-04*<br>-2.05E-04*  | -0.7839<br>-12756.1<br>1.79E-13<br>1.5555<br>3.82E-03<br>-6.21E-06*<br>-6.83E-08* | -0.7028<br>-14228.5<br>1.93E-14<br>2.6617<br>2.14E-01<br>-4.15E-09*             | -0.6381<br>-15671.4<br>1.4711<br>2.6617<br>2.14E-01<br>-4.15E-09*               |
| 1                  | 6.4311<br>1554.9<br>3.23E-01<br>1.2089<br>3.00E-01<br>2.20E+02<br>2.21E+02  | -66.5097<br>-150.4<br>2.73E-02<br>1.2757<br>2.80E-01<br>-1.48E-02<br>-1.44E-02 | -5.4745<br>-1826.6<br>3.43E-01<br>1.3083<br>2.53E-01<br>-3.09E+02<br>-3.08E+02   | -2.8786<br>-3473.9<br>2.42E-01<br>1.3617<br>2.30E-01<br>-1.31E+03<br>-1.31E+03  | -1.9638<br>-5092.2<br>5.93E+02<br>1.4265<br>1.5085<br>-8.40E+02<br>-8.46E+02    | -1.4967<br>-6681.5<br>6.36E-03<br>1.6243<br>1.8408<br>-1.56E+02<br>-8.52E+00                                    | -1.2133<br>-8241.7<br>2.91E-04<br>1.6243<br>1.8408<br>(-7.03E-02)(-4.11E-31)(-6.72E-05)(-7.15E-15)<br>(-7.03E-02)(-4.11E-31)(-6.72E-05)(-7.15E-15) | -1.0232<br>-9772.8<br>4.09E-06<br>1.45E-05<br>1.70E-14<br>-4.96E-02*<br>-4.96E-02* | -0.8869<br>-11274.6<br>4.91E-10<br>5.4968<br>1.6163<br>-1.92E-03*<br>-1.92E-03*   | -0.7845<br>-12747.0<br>5.99E-10<br>3.3927<br>1.6163<br>-4.42E-05*<br>-1.11E-06* | -0.7047<br>-14189.9<br>6.99E-13<br>3.3927<br>4.20E-05<br>-1.11E-06*             |
| 2                  | 3.3206<br>3011.5<br>1.39E-01<br>1.1727<br>3.09E-01<br>7.36E+02<br>7.39E+02  | 7.6556<br>1306.2<br>2.11E-01<br>1.2189<br>2.97E-01<br>8.40E+01<br>8.37E+01     | -27.0233<br>-370.1<br>2.39E-02<br>1.2372<br>2.66E-01<br>-2.26E+02<br>-2.15E-01   | -4.9570<br>-2017.3<br>1.92E-01<br>1.3208<br>2.49E-01<br>-1.85E+03<br>-1.85E+03  | -2.7506<br>-3635.6<br>3.05E-01<br>1.3711<br>2.27E-01<br>-1.67E+03<br>-1.68E+03  | -1.9139<br>-5224.9<br>1.12E-01<br>1.4355<br>1.5182<br>-1.6367<br>-1.6863  | -1.4738<br>-6785.1<br>1.57E-02<br>1.5182<br>1.6367<br>1.8683<br>-35.1380   | -1.2025<br>-8316.2<br>8.60E-04<br>1.31E-05<br>1.57E-01<br>8.83E-02<br>0.00E+00     | -1.0185<br>-9818.0<br>2.13E-11<br>2.13E-11<br>1.57E-01<br>0.00E+00<br>1.44E-01    | -0.8857<br>-11290.5<br>3.07E-09<br>1.6765<br>-35.1380<br>0.00E+00<br>-1.59E-04* | -0.7853<br>-12733.4<br>3.07E-09<br>1.6765<br>-35.1380<br>0.00E+00<br>-1.59E-04* |
| 3                  | 2.2505<br>4443.4<br>4.91E-02<br>1.1405<br>3.16E-01<br>8.73E+02<br>8.79E+02  | 3.6522<br>2738.1<br>1.95E-01<br>1.1809<br>3.07E-01<br>7.62E+02<br>7.63E+02     | 9.4180<br>1061.8<br>6.89E-02<br>1.2330<br>2.93E-01<br>1.43E+01<br>1.41E+01       | -17.0795<br>-585.5<br>1.07E-01<br>1.2590<br>2.85E-01<br>-3.54E+00<br>-3.57E+00  | -4.5376<br>-2203.8<br>6.86E-02<br>1.3397<br>2.60E-01<br>-1.00E+02<br>-9.87E+01  | -2.6364<br>-3793.1<br>3.11E-01<br>1.3812<br>2.46E-01<br>-2.08E+03<br>-2.08E+03                                  | -1.8680<br>-5353.3<br>1.69E-01<br>1.4448<br>2.24E-01<br>-2.62E+03<br>-2.64E+03   | -1.4526<br>-6884.4<br>3.01E-02<br>1.5281<br>1.94E-01<br>-7.49E+02<br>-7.52E+02     | -1.1924<br>-8386.2<br>1.93E-03<br>1.6496<br>1.52E-01<br>8.08E-02<br>-5.19E+01*    | -1.0143<br>-9858.6<br>3.11E-05<br>1.8995<br>1.2926<br>3.23E-04<br>-2.19E-01*    | -0.8848<br>-11301.5<br>9.53E-09<br>-1.2926<br>3.23E-04<br>-2.19E-01*            |
| 4                  | 1.7092<br>5850.6<br>1.55E-02<br>1.1115<br>3.22E-01<br>6.53E+02<br>6.60E+02  | 2.4124<br>4145.3<br>1.07E-01<br>1.1480<br>3.15E-01<br>4.57E+02<br>1.53E+03     | 4.0502<br>2469.0<br>1.62E-01<br>1.1899<br>3.05E-01<br>1.43E+01<br>3.46E-01*      | 12.1693<br>821.7<br>4.31E-03<br>1.2842<br>2.78E-01<br>2.82E-01<br>-1.26E+01     | -12.5540<br>-796.6<br>1.54E-01<br>1.2708<br>2.80E-01<br>2.41E-01<br>-1.37E+01   | -4.1914<br>-2385.8<br>8.57E-03<br>1.3962<br>2.46E-01<br>2.42E-01<br>-2.01E+03                                   | -2.5342<br>-3946.1<br>2.75E-01<br>1.3962<br>2.42E-01<br>2.20E-01<br>-3.56E+03  | -1.8258<br>-5477.1<br>2.21E-01<br>1.3922<br>2.42E-01<br>2.20E-01<br>-3.56E+03      | -1.4329<br>-6978.9<br>4.93E-02<br>1.4545<br>1.91E-01<br>1.48E-01<br>-9.75E+01     | -1.1832<br>-8451.4<br>3.65E-03<br>1.5383<br>1.6631<br>1.9357<br>(-6.21E-01)     | -1.0107<br>-9894.3<br>6.00E-05<br>1.9357<br>1.6631<br>1.9357<br>-1.0107         |
| 5                  | 1.3825<br>7233.4<br>4.61E-03<br>1.0850<br>3.27E-01<br>3.79E+02<br>3.83E+02* | 1.8090<br>5528.1<br>4.60E-02<br>1.1187<br>3.21E-01<br>1.62E+03<br>1.63E+03     | 2.5962<br>3851.8<br>1.37E-01<br>1.1559<br>3.13E-01<br>1.55E+03<br>1.55E+03       | 4.5362<br>2204.5<br>9.29E-02<br>1.2005<br>3.02E-01<br>1.84E+02<br>1.82E+02      | 17.0594<br>586.2<br>9.44E-03<br>1.1959<br>3.03E-01<br>3.53E-01<br>3.72E-01*     | -9.9691<br>-1003.1<br>1.49E-01<br>1.2819<br>2.78E-01<br>2.36E+01<br>-2.35E+01                                   | -3.9012<br>-2563.3<br>2.90E-03<br>1.2027<br>3.01E-01<br>-8.98E+00<br>-9.97E+00*  | -2.4424<br>-4094.4<br>2.17E-01<br>1.4047<br>2.38E-01<br>-1.70E+03<br>-1.69E+03     | -1.7869<br>-5596.2<br>2.63E-01<br>1.4645<br>2.17E-01<br>1.48E-01<br>-4.40E+03     | -1.4147<br>-7068.6<br>7.27E-02<br>1.5488<br>1.4645<br>1.48E-01<br>-1.82E+03     | -1.1749<br>-8511.5<br>6.09E-03<br>1.6773<br>1.6631<br>1.9357<br>-1.1749         |
| 6                  | 1.1639<br>8591.7<br>1.33E-03<br>1.0607<br>3.31E-01<br>1.87E+02<br>1.90E+02* | 1.4521<br>6886.4<br>1.74E-02<br>1.0921<br>3.19E-01<br>2.31E+03<br>2.32E+03     | 1.9193<br>5210.1<br>7.90E-02<br>1.1260<br>3.11E-01<br>1.16E+03<br>1.16E+03       | 2.8067<br>3562.8<br>1.31E-01<br>1.1642<br>2.98E-01<br>4.41E+01<br>4.30E+01      | 5.1426<br>1944.5<br>3.34E-02<br>1.2162<br>2.95E-01<br>3.63E-01<br>3.69E-01      | 28.1484<br>355.3<br>4.59E-02<br>1.2258<br>2.75E-01<br>2.91E-01<br>-2.91E+01                                     | -8.2991<br>-1205.0<br>1.10E-01<br>1.2940<br>2.73E-01<br>-9.01E+01<br>-9.25E+01   | -3.6549<br>-2736.0<br>2.91E-02<br>1.2989<br>2.73E-01<br>-9.01E+01<br>-9.25E+01     | -2.3597<br>-4237.8<br>1.52E-01<br>1.4195<br>2.33E-01<br>-1.27E+03<br>-1.40E+03    | -1.7512<br>-5710.3<br>2.92E-01<br>1.4750<br>2.13E-01<br>1.83E-01<br>-2.34E+03   | -1.3980<br>-7153.2<br>9.92E-02<br>1.5596<br>1.4750<br>1.5596<br>-1.3980         |
| 7                  | 1.0075<br>9925.8<br>3.78E-04<br>1.0384<br>3.35E-01<br>8.38E+01<br>8.53E+01* | 1.2165<br>8220.5<br>6.09E-03<br>1.0677<br>3.25E-01<br>7.48E+02<br>7.58E+02*    | 1.5281<br>6544.2<br>3.73E-02<br>1.0992<br>3.18E-01<br>2.23E+03<br>2.25E+03       | 2.0421<br>4896.9<br>1.01E-01<br>1.1337<br>3.09E-01<br>6.68E+02<br>6.64E+02      | 3.0501<br>3278.6<br>9.83E-02<br>1.1734<br>2.83E-01<br>2.70E+00<br>2.47E+00*     | 5.9196<br>1689.3<br>3.44E-03<br>1.2656<br>2.1309<br>3.00E-02<br>3.03E-02  | 77.4629<br>129.1<br>8.13E-02<br>1.2393<br>1.3090<br>-2.50E+01<br>-2.50E+01   | -7.1328<br>-1402.0<br>6.27E-02<br>1.3215<br>1.4384<br>-2.30E+02<br>-2.33E+02       | -3.4438<br>-2903.8<br>6.56E-02<br>1.3215<br>1.4384<br>-8.21E+02<br>-8.12E+02      | -2.2851<br>-4376.2<br>9.47E-02<br>1.4860<br>2.09E-01<br>-5.38E+03<br>-5.39E+03  | -1.7185<br>-5819.1<br>3.08E-01<br>1.4860<br>2.09E-01<br>-5.38E+03<br>-5.39E+03  |

Table 4. Radiative transition parameters for  $N_2$   $W\ 3\Delta_u - B\ 3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v'\backslash v''$   | 11          | 12          | 13          | 14          | 15          | 16          | 17          | 18          | 19          | 20         | 21        |
|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-----------|
| 0  | -.5853      | -.5415      | -.5045      | -.4730      | -.4457      | -.4220      | -.4012      | -.3828      | -.3665      | -.3519     | -.3387    |
|  | -17084.6    | -18467.8    | -19820.8    | -21143.4    | -22435.3    | -23696.1    | -24925.4    | -26123.0    | -27288.3    | -28421.1   | -29520.7  |
| 1.36E-16   | 2.82E-17    | 1.19E-17    | 1.30E-17    | 1.15E-16    | 1.98E-17    | 1.23E-16    | 4.55E-16    | 2.75E-16    | 2.71E-19    | 3.55E-16   |           |
| 2.3841   | 1.3515      | 1.8307      | 1.1748      | 1.4071      | 1.7176      | 1.1610      | 1.2731      | 1.3329      | -1.4147     | 1.2060     |           |
| 1.41E-02   | 2.56E-01    | 9.80E-02    | 3.08E-01    | 2.37E-01    | 1.30E-01    | 3.12E-01    | 2.81E-01    | 2.62E-01    | 1.45E-04    | 3.00E-01   |           |
| (-2.74E-13)(-2.36E-11)(-1.80E-12)(-2.37E-11)   | -1.47E-10   | (-9.09E-12) | -3.74E-10   | -1.30E-09   | -7.77E-10   | (-2.66E-19) | -1.67E-09   |             |             |            |           |
| -1.42E-11*   | -2.14E-11*  | -1.46E-12*  | -2.66E-11*  | -1.57E-10*  | -1.28E-11*  | -3.77E-10*  | -1.30E-09*  | -7.91E-10*  | -1.30E-11*  | -1.66E-09* |           |
| 1  | -.6409      | -.5887      | -.5453      | -.5086      | -.4772      | -.4502      | -.4265      | -.4058      | -.3875      | -.3712     | -.3566    |
|  | -15603.1    | -16986.3    | -18339.4    | -19662.0    | -20953.8    | -22214.6    | -23443.9    | -24641.5    | -25806.9    | -26939.6   | -28039.3  |
| 2.78E-13   | 4.33E-17    | 3.55E-15    | 7.72E-16    | 2.81E-16    | 1.89E-15    | 1.67E-15    | 2.88E-16    | 1.57E-16    | 1.18E-15    | 1.71E-15   |           |
| 1.5623   | 7.2107      | 1.4228      | 1.3136      | 1.1617      | 1.2070      | 1.2128      | 1.2404      | 1.1221      | 1.1690      | 1.1817     |           |
| 1.82E-01   | 2.87E-26    | 2.31E-01    | 2.68E-01    | 3.11E-01    | 3.00E-01    | 2.98E-01    | 2.91E-01    | 3.20E-01    | 3.10E-01    | 3.07E-01   |           |
| (-7.08E-08)(0.00E+00)  | -2.37E-09   | -8.57E-10   | -5.07E-10   | -3.78E-09   | -3.88E-09   | -7.37E-10   | -5.60E-10   | -4.47E-09   | -7.17E-09   |            |           |
| -3.97E-08*   | -1.25E-09*  | -2.33E-09*  | -9.42E-10*  | -4.65E-10*  | -3.72E-09*  | -3.88E-09*  | -7.51E-10*  | -5.57E-10*  | -4.46E-09*  | -7.13E-09* |           |
| 2  | -.7069      | -.6439      | -.5923      | -.5493      | -.5129      | -.4817      | -.4548      | -.4313      | -.4107      | -.3924     | -.3762    |
|  | -14146.5    | -15529.7    | -16882.8    | -18205.4    | -19497.2    | -20758.0    | -21987.3    | -23184.9    | -24350.3    | -25483.0   | -26582.7  |
| 4.14E-13   | 1.52E-12    | 1.82E-15    | 8.53E-16    | 1.45E-15    | 4.43E-15    | 2.48E-15    | 1.70E-17    | 1.89E-15    | 4.77E-15    | 4.15E-15   |           |
| 7.2072   | 1.6800      | -.8581      | 2.3934      | 1.0616      | 1.2007      | 1.2332      | 1.7327      | 1.1577      | 1.1787      | 1.1715     |           |
| 3.06E-26   | 1.42E-01    | 3.89E-03    | 1.36E-02    | 3.31E-01    | 3.02E-01    | 2.93E-01    | 1.26E-01    | 3.12E-01    | 3.07E-01    | 3.09E-01   |           |
| (0.00E+00)(-2.33E-07)(-2.69E-13)(-1.92E-12)  | -2.38E-09   | -7.31E-09   | -4.57E-09   | (-6.82E-12) | -5.39E-09   | -1.51E-08   | -1.51E-08   |             |             |            |           |
| -8.76E-06*   | -9.08E-08*  | -1.57E-08*  | -1.06E-10*  | -2.30E-09*  | -6.96E-09*  | -4.48E-09*  | -1.12E-11*  | -5.32E-09*  | -1.49E-08*  | -1.48E-08* |           |
| 3  | -.7865      | -.7093      | -.6472      | -.5962      | -.5535      | -.5174      | -.4865      | -.4597      | -.4363      | -.4158     | -.3976    |
|  | -12714.7    | -14097.9    | -15450.9    | -16773.5    | -18065.4    | -19326.1    | -20555.5    | -21753.1    | -22918.4    | -24051.2   | -25150.8  |
| 1.12E-08   | 1.95E-12    | 7.31E-12    | 1.28E-13    | 1.62E-15    | 1.79E-15    | 5.51E-17    | 1.53E-15    | 4.92E-15    | 6.49E-15    | 5.41E-15   |           |
| 1.7371   | -3.5191     | 1.7557      | .8232       | -.7847      | .9097       | 1.2572      | 1.1105      | 1.1109      | 1.0994      | 1.0831     |           |
| 1.25E-01   | 1.73E-13    | 1.19E-01    | 3.41E-01    | 5.61E-03    | 3.44E-01    | 2.86E-01    | 3.23E-01    | 3.23E-01    | 3.25E-01    | 3.28E-01   |           |
| (-7.21E-04)(-3.33E-31)(-7.74E-07)(-1.42E-07)(-6.12E-13)(-3.10E-09)(-7.93E-11)            | -3.31E-09   | -1.25E-08   | -1.93E-08   | -3.58E-09*  | -2.82E-11*  | -3.48E-09*  | -1.25E-08*  | -1.91E-08*  | -1.85E-08*  |            |           |
| -3.78E-04*   | -4.44E-05*  | -2.10E-07*  | -1.97E-07*  | -1.92E-08*  | -3.58E-09*  | -2.82E-11*  | -3.48E-09*  | -1.25E-08*  | -1.91E-08*  | -1.85E-08* |           |
| 4  | -.8844      | -.7880      | -.7121      | -.6508      | -.6003      | -.5581      | -.5222      | -.4915      | -.4649      | -.4416     | -.4212    |
|  | -11307.4    | -12690.7    | -14043.7    | -15366.3    | -16658.1    | -17918.9    | -19148.3    | -20345.8    | -21511.2    | -22643.9   | -23743.6  |
| 9.05E-08   | 3.18E-08    | 5.50E-11    | 2.59E-11    | 7.91E-13    | 8.98E-16    | 8.00E-15    | 9.78E-15    | 1.21E-14    | 1.37E-14    | 1.45E-14   |           |
| .2061  | 1.8022      | -.0527      | 1.8454      | 1.0576      | 6.7755      | 1.5286      | 1.1170      | 1.0403      | 1.0218      | 1.0196     |           |
| 1.71E-01   | 1.06E-01    | 9.23E-02    | 9.41E-02    | 3.32E-01    | 6.27E-23    | 1.94E-01    | 3.21E-01    | 3.34E-01    | 3.37E-01    | 3.37E-01   |           |
| (-7.76E-03)(-1.47E-03)(-2.63E-06)(-1.68E-06)(-8.16E-07)(0.00E+00)                        | -4.28E-09   | -1.72E-08   | -2.72E-08   | -3.66E-08   | -4.46E-08   | -1.72E-08   | -2.72E-08   | -3.66E-08   | -4.46E-08   |            |           |
| -1.00E-01*   | -5.99E-04*  | -1.67E-04*  | -1.65E-07*  | -7.40E-07*  | -2.91E-08*  | -4.58E-09*  | -1.88E-08*  | -2.90E-08*  | -3.78E-08*  | -4.50E-08* |           |
| 5  | -1.0076     | -.8843      | -.7898      | -.7151      | -.6546      | -.6047      | -.5629      | -.5273      | -.4968      | -.4703     | -.4472    |
|  | -9924.7     | -11307.9    | -12661.0    | -13983.6    | -15275.4    | -16536.2    | -17765.5    | -18963.1    | -20128.5    | -21261.2   | -22360.9  |
| 9.93E-05   | 4.43E-07    | 7.49E-08    | 4.51E-10    | 6.57E-11    | 3.15E-12    | 1.56E-14    | 6.48E-14    | 5.47E-14    | 5.83E-14    | 6.74E-14   |           |
| 1.9786   | .7464       | 1.8745      | .7151       | 1.9845      | 1.2415      | 3.5411      | 1.4036      | 1.0737      | 1.0056      | 1.0046     |           |
| 6.37E-02   | 3.32E-01    | 8.68E-02    | 3.27E-01    | 6.25E-02    | 2.90E-01    | 1.39E-05    | 2.38E-01    | 3.29E-01    | 3.38E-01    | 3.39E-01   |           |
| (-7.97E-01)(-1.43E-01)(-2.32E-03)(-2.68E-04)(-1.85E-06)(-2.44E-06)(-3.45E-17)(-5.08E-08) | -9.80E-08   | -1.30E-07   | -1.75E-07   | -2.99E-07   | -4.45E-08*  | -1.02E-07*  | -1.39E-07*  | -1.81E-07*  |             |            |           |
| -2.29E-01*   | -2.43E-01*  | -5.50E-04*  | -5.16E-04*  | -2.47E-07*  | -1.74E-06*  | -5.07E-08*  | -4.45E-08*  | -1.02E-07*  | -1.39E-07*  | -1.81E-07* |           |
| 6  | -1.1674     | -1.0051     | -.8848      | -.7921      | -.7185      | -.6589      | -.6095      | -.5680      | -.5328      | -.5024     | -.4761    |
|  | -8566.3     | -9949.6     | -11302.6    | -12625.2    | -13917.0    | -15177.8    | -16407.2    | -17604.7    | -18770.1    | -19902.8   | -21002.5  |
| 9.29E-03   | 1.44E-04    | 1.55E-06    | 1.50E-07    | 2.30E-09    | 1.30E-10    | 1.16E-11    | 3.46E-14    | 3.40E-13    | 3.24E-13    | 3.39E-13   |           |
| 1.6923   | 2.0310      | 1.0316      | 1.9584      | 1.0624      | 2.1819      | 1.4170      | 3.5677      | 1.3506      | 1.0726      | 1.0176     |           |
| 1.38E-01   | 5.38E-02    | 3.35E-01    | 6.78E-02    | 3.31E-01    | 3.18E-02    | 2.33E-01    | 1.14E-05    | 2.56E-01    | 3.29E-01    | 3.37E-01   |           |
| -2.27E+02  | (-8.35E-01) | -5.12E-01   | (-2.81E-03) | -1.38E-03   | (-9.25E-07) | (-5.67E-06) | (-4.93E-17) | (-5.08E-08) | -9.80E-08   | -1.30E-07  | -1.75E-07 |
| -2.16E+02*   | -8.28E-02*  | -5.17E-01*  | -1.04E-04*  | -1.35E-03*  | -8.58E-06*  | -3.38E-06*  | -1.14E-07*  | -2.41E-07*  | -5.62E-07*  | -7.53E-07* |           |
| 7  | -1.3827     | -1.1607     | -1.0032     | -.8856      | -.7947      | -.7223      | -.6634      | -.6146      | -.5735      | -.5385     | -.5084    |
|  | -7232.3     | -8615.5     | -9968.6     | -11291.1    | -12583.0    | -13843.8    | -15073.1    | -16270.7    | -17436.1    | -18568.8   | -19668.4  |
| 1.28E-01   | 1.32E-02    | 1.86E-04    | 4.40E-06    | 2.56E-07    | 8.78E-09    | 1.83E-10    | 3.57E-11    | 7.44E-14    | 1.63E-12    | 1.60E-12   |           |
| 1.5708   | 1.7081      | 2.0976      | 1.2131      | 2.0635      | 1.2702      | 2.5240      | 1.5880      | 3.1578      | 1.3087      | 1.0827     |           |
| 1.79E-01   | 1.33E-01    | 4.30E-02    | 2.98E-01    | 4.83E-02    | 2.82E-01    | 7.51E-03    | 1.73E-01    | 2.12E-04    | 2.70E-01    | 3.28E-01   |           |
| -3.14E+03  | -3.04E+02   | (-6.91E-01) | (-1.14E+00) | (-2.41E-03) | (-3.75E-03) | (-7.18E-08) | (-9.34E-06) | (-3.59E-14) | (-1.54E-06) | -2.65E-06  |           |
| -3.14E+03  | -2.88E+02   | -8.19E-03*  | -9.78E-01*  | -5.67E-04*  | -3.00E-03*  | -6.42E-05*  | -4.24E-06*  | -1.20E-07*  | -1.21E-06*  | -2.55E-06* |           |

Table 4. Radiative transition parameters for  $N_2 W^3\Delta_u - B^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| V' \ V''  | 0         | 1         | 2         | 3         | 4         | 5         | 6         | 7           | 8          | 9           | 10       |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-------------|------------|-------------|----------|
| 8         | .8900     | 1.0493    | 1.2732    | 1.6112    | 2.1794    | 3.3343    | 6.9497    | -108.4975   | -6.2736    | -3.2611     | -2.2176  |
|           | 11235.6   | 9530.3    | 7854.0    | 6206.7    | 4588.4    | 2999.1    | 1438.9    | -92.2       | -1594.0    | -3066.4     | -4509.3  |
| 1.07E-04  | 2.04E-03  | 1.56E-02  | 5.92E-02  | 1.05E-01  | 5.73E-02  | 2.81E-03  | 9.88E-02  | 2.48E-02    | 9.74E-02   | 4.98E-02    |          |
| 1.0177    | 1.0453    | 1.0747    | 1.1065    | 1.1416    | 1.1844    | 1.1449    | 1.2503    | 1.3328      | 1.3358     | 1.4658      |          |
| 3.37E-01  | 3.34E-01  | 3.29E-01  | 3.23E-01  | 3.16E-01  | 3.06E-01  | 3.15E-01  | 2.88E-01  | 2.62E-01    | 2.61E-01   | 2.16E-01    |          |
| 3.51E+01  | 3.99E+02  | 1.66E+03  | 3.00E+03  | 2.06E+03  | 2.93E+02  | 1.69E+00  | -1.30E-02 | -1.40E+01   | -3.88E+02  | -4.33E+02   |          |
| 3.57E+01* | 4.05E+02* | 1.68E+03  | 3.02E+03  | 2.06E+03  | 2.89E+02  | 1.86E+00* | -1.30E-02 | -1.35E+01   | -3.91E+02  | -4.26E+02   |          |
| 9         | .7986     | .9266     | 1.0941    | 1.3347    | 1.7024    | 2.3339    | 3.6704    | 8.3791      | -32.4286   | -5.6154     | -3.1020  |
|           | 12521.2   | 10815.9   | 9139.6    | 7492.3    | 5874.0    | 4284.7    | 2724.5    | 1193.4      | -308.4     | -1780.8     | -3223.7  |
| 3.07E-05  | 6.68E-04  | 6.10E-03  | 2.94E-02  | 7.66E-02  | 9.22E-02  | 2.31E-02  | 2.06E-02  | 9.57E-02    | 4.10E-03   | 1.17E-01    |          |
| .9986     | 1.0246    | 1.0523    | 1.0819    | 1.1140    | 1.1501    | 1.2001    | 1.1958    | 1.2610      | 1.4012     | 1.3478      |          |
| 3.39E-01  | 3.36E-01  | 3.33E-01  | 3.28E-01  | 3.22E-01  | 3.14E-01  | 3.02E-01  | 3.03E-01  | 2.85E-01    | 2.39E-01   | 2.57E-01    |          |
| 1.41E+01  | 1.94E+02  | 1.04E+03  | 2.70E+03  | 3.26E+03  | 1.45E+03  | 8.61E+01  | 6.52E+00  | -4.61E-01   | -2.68E+00  | -5.25E+02   |          |
| 1.43E+01* | 1.97E+02* | 1.06E+03* | 2.72E+03  | 3.27E+03  | 1.45E+03  | 8.36E+01  | 6.73E+00  | -4.59E-01   | -2.44E+00* | -5.26E+02   |          |
| 10        | .7255     | .8280     | .9614     | 1.1424    | 1.4014    | 1.8030    | 2.5088    | 4.0735      | 10.4922    | -19.2549    | -5.0962  |
|           | 13782.6   | 12077.3   | 10401.1   | 8753.8    | 7135.5    | 5546.2    | 3986.0    | 2454.9      | 953.1      | -519.3      | -1962.2  |
| 8.89E-06  | 2.16E-04  | 2.28E-03  | 1.32E-02  | 4.50E-02  | 8.45E-02  | 6.78E-02  | 3.79E-03  | 4.37E-02    | 7.76E-02   | 5.15E-04    |          |
| .9809     | 1.0054    | 1.0315    | 1.0593    | 1.0891    | 1.1217    | 1.1594    | 1.2400    | 1.2122      | 1.2725     | 1.0226      |          |
| 3.41E-01  | 3.39E-01  | 3.35E-01  | 3.32E-01  | 3.27E-01  | 3.20E-01  | 3.12E-01  | 2.91E-01  | 2.99E-01    | 2.81E-01   | 3.37E-01    |          |
| 5.48E+00  | 8.85E+01  | 5.84E+02  | 1.90E+03  | 3.54E+03  | 3.00E+03  | 8.47E+02  | 9.61E+00  | 6.84E+00    | -1.74E+00  | (-8.94E-01) |          |
| 5.60E+00* | 9.02E+01* | 5.94E+02* | 2.00E+03  | 3.56E+03  | 3.00E+03  | 8.39E+02  | 8.86E+00* | 6.95E+00    | -1.73E+00  | -1.23E+00*  |          |
| 11        | .6658     | .7511     | .8592     | 1.0009    | 1.1943    | 1.4742    | 1.9145    | 2.7084      | 4.5654     | 13.9282     | -13.7945 |
|           | 15020.0   | 13314.7   | 11638.4   | 9991.1    | 8372.8    | 6783.5    | 5223.3    | 3692.2      | 2190.4     | 718.0       | -724.9   |
| 2.62E-06  | 7.00E-05  | 8.27E-04  | 5.60E-03  | 2.33E-02  | 5.89E-02  | 8.13E-02  | 4.06E-02  | 5.35E-04    | 6.20E-02   | 5.29E-02    |          |
| .9645     | .9876     | 1.0122    | 1.0385    | 1.0664    | 1.0965    | 1.1298    | 1.1705    | 1.0506      | 1.2241     | 1.2857      |          |
| 3.42E-01  | 3.40E-01  | 3.38E-01  | 3.35E-01  | 3.30E-01  | 3.25E-01  | 3.19E-01  | 3.09E-01  | 3.33E-01    | 2.95E-01   | 2.77E-01    |          |
| 2.10E+00  | 3.87E+01  | 3.02E+02  | 1.27E+03  | 3.02E+03  | 3.94E+03  | 2.38E+03  | 3.97E+02  | ( 1.26E+00) | 4.06E+00   | -3.14E+00   |          |
| 2.15E+00* | 3.95E+01* | 3.07E+02* | 1.28E+03* | 3.05E+03  | 3.96E+03  | 2.38E+03  | 3.90E+02  | 1.59E+00*   | 4.09E+00   | -3.08E+00   |          |
| 12        | .6160     | .6883     | .7781     | .8925     | 1.0432    | 1.2505    | 1.5536    | 2.0386      | 2.9381     | 5.1783      | 20.4814  |
|           | 16233.1   | 14527.8   | 12851.6   | 11204.3   | 9586.0    | 7996.7    | 6436.5    | 4905.4      | 3403.6     | 1931.1      | 488.2    |
| 7.83E-07  | 2.27E-05  | 2.96E-04  | 2.27E-03  | 1.11E-02  | 3.48E-02  | 6.76E-02  | 6.85E-02  | 1.79E-02    | 9.27E-03   | 7.03E-02    |          |
| .9490     | .9709     | .9943     | 1.0191    | 1.0455    | 1.0736    | 1.1041    | 1.1383    | 1.1857      | 1.1677     | 1.2347      |          |
| 3.43E-01  | 3.41E-01  | 3.40E-01  | 3.37E-01  | 3.34E-01  | 3.29E-01  | 3.24E-01  | 3.17E-01  | 3.06E-01    | 3.10E-01   | 2.92E-01    |          |
| 7.97E-01  | 1.65E+01  | 1.47E+02  | 7.34E+02  | 2.20E+03  | 3.91E+03  | 3.83E+03  | 1.64E+03  | 1.34E+02    | 1.30E+01   | 1.42E+00    |          |
| 8.16E-01* | 1.68E+01* | 1.50E+02* | 7.46E+02* | 2.22E+03  | 3.95E+03  | 3.84E+03  | 1.63E+03  | 1.29E+02    | 1.37E+01*  | 1.42E+00    |          |
| 13        | .5740     | .6363     | .7122     | .8069     | .9281     | 1.0886    | 1.3114    | 1.6408      | 2.1774     | 3.2050      | 5.9621   |
|           | 17422.2   | 15716.8   | 14040.6   | 12393.3   | 10775.0   | 9185.7    | 7625.5    | 6094.4      | 4592.6     | 3120.2      | 1677.3   |
| 2.38E-07  | 7.42E-06  | 1.06E-04  | 8.95E-04  | 4.97E-03  | 1.86E-02  | 4.59E-02  | 6.94E-02  | 5.01E-02    | 4.05E-03   | 2.38E-02    |          |
| .9342     | .9552     | .9775     | 1.0011    | 1.0261    | 1.0526    | 1.0810    | 1.1119    | 1.1477      | 1.2182     | 1.1890      |          |
| 3.43E-01  | 3.42E-01  | 3.41E-01  | 3.39E-01  | 3.36E-01  | 3.33E-01  | 3.28E-01  | 3.22E-01  | 3.15E-01    | 2.97E-01   | 3.05E-01    |          |
| 3.00E-01  | 6.85E+00  | 6.88E+01  | 3.97E+02  | 1.42E+03  | 3.23E+03  | 4.44E+03  | 3.30E+03  | 9.73E+02    | 2.20E+01   | 2.11E+01    |          |
| 3.08E-01* | 7.01E+00* | 7.03E+01* | 4.04E+02* | 1.45E+03* | 3.26E+03  | 4.47E+03  | 3.31E+03  | 9.62E+02    | 2.04E+01*  | 2.17E+01    |          |
| 14        | .5380     | .5924     | .6577     | .7376     | .8375     | .9661     | 1.1376    | 1.3776      | 1.7369     | 2.3337      | 3.5186   |
|           | 18587.0   | 16881.7   | 15205.4   | 13558.1   | 11939.8   | 10350.5   | 8790.3    | 7259.2      | 5757.4     | 4285.0      | 2842.1   |
| 7.30E-08  | 2.44E-06  | 3.75E-05  | 3.48E-04  | 2.15E-03  | 9.23E-03  | 2.74E-02  | 5.43E-02  | 6.38E-02    | 3.07E-02   | 1.37E-05    |          |
| .9193     | .9401     | .9616     | .9842     | 1.0079    | 1.0331    | 1.0598    | 1.0884    | 1.1200      | 1.1586     | .3696       |          |
| 3.44E-01  | 3.43E-01  | 3.42E-01  | 3.40E-01  | 3.38E-01  | 3.35E-01  | 3.31E-01  | 3.27E-01  | 3.21E-01    | 3.12E-01   | 2.29E-01    |          |
| 1.12E-01  | 2.80E+00  | 3.12E+01  | 2.04E+02  | 8.49E+02  | 2.33E+03  | 4.15E+03  | 4.49E+03  | 2.54E+03    | 4.77E+02   | ( 3.34E-02) |          |
| 1.15E-01* | 2.87E+00* | 3.20E+01* | 2.08E+02* | 8.64E+02* | 2.36E+03* | 4.19E+03  | 4.51E+03  | 2.53E+03    | 4.68E+02   | 3.25E-01*   |          |
| 15        | .5069     | .5549     | .6118     | .6803     | .7645     | .8702     | 1.0070    | 1.1905      | 1.4497     | 1.8431      | 2.5109   |
|           | 19727.5   | 18022.2   | 16345.9   | 14698.7   | 13080.4   | 11491.1   | 9930.9    | 8399.8      | 6898.0     | 5425.5      | 3982.6   |
| 2.25E-08  | 8.07E-07  | 1.33E-05  | 1.34E-04  | 9.09E-04  | 4.37E-03  | 1.50E-02  | 3.64E-02  | 5.83E-02    | 5.26E-02   | 1.45E-02    |          |
| .9037     | .9251     | .9463     | .9681     | .9909     | 1.0149    | 1.0402    | 1.0671    | 1.0960      | 1.1285     | 1.1731      |          |
| 3.44E-01  | 3.44E-01  | 3.43E-01  | 3.42E-01  | 3.40E-01  | 3.37E-01  | 3.34E-01  | 3.30E-01  | 3.25E-01    | 3.19E-01   | 3.09E-01    |          |
| 4.14E-02  | 1.13E+00  | 1.39E+01  | 1.00E+02  | 4.76E+02  | 1.53E+03  | 3.34E+03  | 4.77E+03  | 4.10E+03    | 1.73E+03   | 1.77E+02    |          |
| 4.26E-02* | 1.16E+00* | 1.42E+01* | 1.03E+02* | 4.85E+02* | 1.55E+03* | 3.38E+03  | 4.80E+03  | 4.11E+03    | 1.72E+03   | 1.71E+02    |          |

Table 4. Radiative transition parameters for  $N_2 W^3\Delta_u - B^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \setminus V''$ | 11         | 12         | 13          | 14   | 15  | 16   | 17   | 18  | 19                                | 20                     | 21         |  |
|--------------------|------------|------------|-------------|--|---|--|--|---|-----------------------------------|------------------------|------------|--|
| 8                  | -1.6885    | -1.3688    | -1.1549     | -1.0019  | -.8871  | -.7978   | -.7266   | -.6684                                      | -.6201                            | -.5794                 | -.5447     |  |
|                    | -5922.5    | -7305.7    | -8658.8     | -9981.3  | -11273.2  | -12534.0   | -13763.3   | -14960.9                                    | -16126.2                          | -17259.0               | -18358.6   |  |
|                    | 3.12E-01   | 1.57E-01   | 1.76E-02    | 2.13E-04   | 1.07E-05  | 3.68E-07   | 2.74E-08   | 1.37E-10                                    | 8.94E-11                          | 9.58E-14               | 5.88E-12   |  |
|                    | 1.4977     | 1.5824     | 1.7250      | 2.1871   | 1.3432  | 2.2075   | 1.4174   | 3.4454                                      | 1.7769                            | 2.4432                 | 1.2793     |  |
|                    | 2.05E-01   | 1.75E-01   | 1.28E-01    | 3.11E-02   | 2.59E-01  | 2.88E-02   | 2.33E-01   | 2.86E-05                                    | 1.13E-01                          | 1.09E-02               | 2.79E-01   |  |
|                    | -5.51E+03  | -3.80E+03  | -3.80E+02   | (-4.17E-01)(-2.07E+00)(-1.22E-03)(-7.89E-03)(-7.59E-13)(-9.67E-06)(-1.18E-10)(-5.75E-06) |   |  |  |   |                                   |                        |            |  |
|                    | -5.53E+03  | -3.80E+03  | -3.57E+02   | -4.83E-01*   | -1.67E+00*  | -7.90E-03*   | -5.73E-03*   | -3.01E-04*                                  | -1.60E-06*                        | -7.38E-09*             | -4.50E-06* |  |
| 9                  | -2.1566    | -1.6611    | -1.3563     | -1.1500  | -1.0012   | -.8890   | -.8014   | -.7312                                      | -.6738                            | -.6260                 | -.5857     |  |
|                    | -4636.9    | -6020.1    | -7373.1     | -8695.7  | -9987.6   | -11248.3   | -12477.7   | -13675.3                                    | -14840.6                          | -15973.4               | -17073.0   |  |
|                    | 2.01E-02   | 3.06E-01   | 1.86E-01    | 2.23E-02   | 2.13E-04  | 2.28E-05   | 4.26E-07   | 7.29E-08                                    | 1.16E-12                          | 1.84E-10               | 1.84E-15   |  |
|                    | 1.5147     | 1.5102     | 1.5944      | 1.7431   | 2.3165  | 1.4446   | 2.4332   | 1.5347                                      | 33.3270                           | 2.0076                 | 7.5240     |  |
|                    | 1.99E-01   | 2.00E-01   | 1.71E-01    | 1.23E-01   | 1.88E-02  | 2.24E-01   | 1.14E-02   | 1.92E-01                                    | 0.00E+00                          | 5.81E-02               | 1.40E-45   |  |
|                    | -1.60E+02  | -5.44E+03  | -4.41E+03   | -4.48E+02  | (-1.51E-01)(-3.30E+00)(-2.17E-04)(-1.39E-02)(0.00E+00)(-5.13E-06)(0.00E+00) |  |  |   |                                   |                        |            |  |
|                    | -1.56E+02  | -5.46E+03  | -4.42E+03   | -4.17E+02  | -2.42E+00*  | -2.59E+00*   | -3.85E-02*   | -9.27E-03*                                  | -1.07E-03*                        | -2.52E-06*             | -4.28E-07* |  |
| 10                 | -2.9626    | -2.1014    | -1.6362     | -1.3451  | -1.1460   | -1.0013  | -.8916   | -.8056                                      | -.7364                            | -.6797                 | -.6324     |  |
|                    | -3375.4    | -4758.6    | -6111.7     | -7434.3  | -8726.1   | -9986.9  | -11216.2   | -12413.8                                    | -13579.2                          | -14711.9               | -15811.6   |  |
|                    | 1.22E-01   | 4.35E-03   | 2.93E-01    | 2.14E-01   | 2.71E-02  | 1.78E-04   | 4.41E-05   | 3.52E-07                                    | 1.68E-07                          | 6.43E-10               | 2.95E-10   |  |
|                    | 1.3590     | 1.6521     | 1.5236      | 1.6069   | 1.7627  | 2.5273   | 1.5295   | 2.8784                                      | 1.6382                            | .3616                  | 2.3409     |  |
|                    | 2.55E-01   | 1.51E-01   | 1.96E-01    | 1.67E-01   | 1.17E-01  | 7.40E-03   | 1.94E-01   | 1.18E-03                                    | 1.56E-01                          | 3.42E-02               | 1.69E-02   |  |
|                    | -6.12E+02  | -2.18E+01  | -5.20E+03   | -4.95E+03  | -4.99E+02   | (-1.96E-02)(-4.73E+00)(-1.90E-06)(-2.08E-02)(-4.85E-06)(-6.79E-07) |  |   |                                   |                        |            |  |
|                    | -6.10E+02  | -2.02E+01* | -5.22E+03   | -4.96E+03  | -4.58E+02   | -7.27E+00*   | -3.63E+00*   | -1.28E-01*                                  | -1.22E-02*                        | -3.07E-03*             | -6.51E-05* |  |
| 11                 | -4.6771    | -2.8398    | -2.0516     | -1.6137  | -1.3353   | -1.1429  | -1.0021  | -.8947                                      | -.8103                            | -.7421                 | -.6861     |  |
|                    | -2138.1    | -3521.3    | -4874.4     | -6196.9  | -7488.8   | -8749.6  | -9978.9  | -11176.5                                    | -12341.8                          | -13474.6               | -14574.2   |  |
|                    | 9.60E-03   | 1.16E-01   | 2.83E-06    | 2.76E-01   | 2.41E-01  | 3.16E-02   | 1.10E-04   | 7.76E-05                                    | 1.30E-07                          | 3.38E-07               | 5.96E-09   |  |
|                    | 1.2505     | 1.3700     | -8.1663     | 1.5380   | 1.6200  | 1.7841   | 2.9491   | 1.6050                                      | 4.3788                            | 1.7389                 | .7487      |  |
|                    | 2.88E-01   | 2.50E-01   | 0.00E+00    | 1.91E-01   | 1.62E-01  | 1.11E-01   | 7.81E-04   | 1.67E-01                                    | 8.23E-09                          | 1.24E-01               | 3.33E-01   |  |
|                    | -1.58E+01  | -6.37E+02  | (0.00E+00)  | -4.84E+03  | -5.40E+03   | (-5.26E+02)(-1.35E-04)(-6.15E+00)(-3.35E-17)(-2.57E-02)(-4.14E-03) |  |   |                                   |                        |            |  |
|                    | -1.66E+01* | -6.33E+02  | -9.38E+00*  | -4.87E+03  | -5.41E+03   | -4.75E+02  | -1.70E+01*   | -4.59E+00*                                  | -3.37E-01*                        | -1.18E-02*             | -7.40E-03* |  |
| 12                 | -10.8118   | -4.3325    | -2.7314     | -2.0065  | -1.5935   | -1.3269  | -1.1408  | -1.0037                                     | -.8986                            | -.8156                 | -.7484     |  |
|                    | -924.9     | -2308.1    | -3661.2     | -4983.8  | -6275.6   | -7536.4  | -8765.7  | -9963.3                                     | -11128.7                          | -12261.4               | -13361.1   |  |
|                    | 2.92E-02   | 2.54E-02   | 1.01E-01    | 3.62E-03   | 2.57E-01  | 2.66E-01   | 3.55E-02   | 3.36E-05                                    | 1.25E-04                          | 1.68E-08               | 5.89E-07   |  |
|                    | 1.3030     | 1.2844     | 1.3814      | 1.5126   | 1.5537  | 1.6336   | 1.8077   | 4.3055                                      | 1.6762                            | -8.0302                | 1.8477     |  |
|                    | 2.72E-01   | 2.78E-01   | 2.46E-01    | 3.14E-01   | 1.85E-01  | 1.58E-01   | 1.04E-01   | 1.71E-08                                    | 1.44E-01                          | 0.00E+00               | 9.35E-02   |  |
|                    | -3.46E+00  | -4.87E+01  | -6.04E+02   | -8.92E+01  | -4.42E+03   | -5.74E+03  | (-5.25E+02)(-1.97E-14)(-7.22E+00)(0.00E+00)(-2.49E-02) |   |                                   |                        |            |  |
|                    | -3.36E+00  | -5.01E+01  | -5.98E+02   | -9.84E+01*   | -4.46E+03   | -5.76E+03  | -4.62E+02  | -3.38E+01*                                  | -5.13E+00*                        | -7.57E-01*             | -5.91E-03* |  |
| 13                 | 37.8656    | -8.9355    | -4.0450     | -2.6352  | -1.9659   | -1.5755  | -1.3198  | -1.1397                                     | -1.0061                           | -.9031                 | -.8216     |  |
|                    | 264.1      | -1119.1    | -2472.2     | -3794.8  | -5086.6   | -6347.4  | -7576.7  | -8774.3                                     | -9939.7                           | -11072.4               | -12172.1   |  |
|                    | 6.80E-02   | 1.16E-02   | 4.24E-02    | 8.14E-02   | 1.19E-02  | 2.39E-01   | 2.90E-01   | 3.83E-02                                    | 1.01E-06                          | 1.86E-04               | 9.38E-07   |  |
|                    | 1.2452     | 1.3317     | 1.3023      | 1.3936   | 1.2779  | 1.5708   | 1.6479   | 1.8343                                      | -15.1450                          | 1.7477                 | .0993      |  |
|                    | 2.89E-01   | 2.63E-01   | 2.72E-01    | 2.42E-01   | 2.80E-01  | 1.79E-01   | 1.53E-01   | 9.70E-02                                    | 0.00E+00                          | 1.21E-01               | 1.36E-01   |  |
|                    | 2.13E-01   | -2.26E+00  | -9.60E+01   | -5.26E+02  | -2.48E+02   | -3.97E+03  | -5.97E+03  | (-4.93E+02)(0.00E+00)(-7.53E+00)(-6.32E-02) |                                   |                        |            |  |
|                    | 2.12E-01   | -2.15E+00  | -9.75E+01   | -5.19E+02  | -2.54E+02   | -4.02E+03  | -6.01E+03  | -4.19E+02                                   | -6.01E+01*                        | 4.86E+00*              | 1.49E+00*  |  |
| 14                 | 6.9984     | 218.9094   | -7.6490     | -3.8024  | -2.5499   | -1.9295  | -1.5596  | -1.3141                                     | -1.1396                           | -1.0093                | -.9085     |  |
|                    | 1428.9     | 45.7       | -1307.4     | -2629.9  | -3921.8   | -5182.6  | -6411.9  | -7609.5                                     | -8774.8                           | -9907.6                | -11007.2   |  |
|                    | 3.82E-02   | 5.76E-02   | 2.01E-03    | 5.66E-02   | 6.15E-02  | 2.20E-02   | 2.22E-01   | 3.12E-01                                    | 3.97E-02                          | 1.03E-04               | 2.52E-04   |  |
|                    | 1.2022     | 1.2562     | 1.4175      | 1.3154   | 1.4070  | 1.3215   | 1.5893   | 1.6629                                      | 1.8648                            | -.1021                 | 1.8247     |  |
|                    | 3.01E-01   | 2.86E-01   | 2.33E-01    | 2.68E-01   | 2.37E-01  | 2.66E-01   | 1.73E-01   | 1.48E-01                                    | 8.92E-02                          | 8.02E-02               | 9.96E-02   |  |
|                    | 2.05E+01   | 9.11E-04   | (-4.94E-01) | -1.50E+02  | -4.22E+02   | -4.38E+02  | -3.54E+03  | -6.09E+03                                   | (-4.32E+02)(-1.30E+00)(-6.74E+00) |                        |            |  |
|                    | 2.08E+01   | 9.02E-04   | -4.33E-01*  | -1.51E+02  | -4.14E+02   | -4.40E+02  | -3.61E+03  | -6.14E+03                                   | -3.48E+02                         | -9.73E+01*             | -3.56E+00* |  |
| 15                 | 3.8919     | 8.4300     | -59.9535    | -6.7142  | -3.5955   | -2.4740  | -1.8970  | -1.5459                                     | -1.3099                           | -1.1406                | -1.0135    |  |
|                    | 2569.5     | 1186.2     | -166.8      | -1489.4  | -2781.2   | -4042.0  | -5271.4  | -6468.9                                     | -7634.3                           | -8767.0                | -9866.7    |  |
|                    | 4.10E-03   | 4.83E-02   | 4.29E-02    | 1.86E-04   | 6.61E-02  | 4.33E-02   | 3.18E-02   | 2.09E-01                                    | 3.32E-01                          | 3.92E-02               | 4.75E-04   |  |
|                    | 1.1402     | 1.2132     | 1.2684      | .8542  | 1.3265  | 1.4223   | 1.3429   | 1.6095                                      | 1.6787                            | 1.9008                 | .8300      |  |
|                    | 3.16E-01   | 2.98E-01   | 2.83E-01    | 3.43E-01   | 2.64E-01  | 2.32E-01   | 2.59E-01   | 1.66E-01                                    | 1.43E-01                          | 8.05E-02               | 3.42E-01   |  |
|                    | 1.41E+01   | 1.46E+01   | -3.22E-02   | (-1.47E-01)  | -2.01E+02   | -3.11E+02  | -6.33E+02  | -3.15E+03                                   | -6.10E+03                         | (-3.47E+02)(-1.08E+02) |            |  |
|                    | 1.52E+01*  | 1.47E+01   | -3.16E-02   | -2.74E-01*   | -2.02E+02   | -3.03E+02  | -6.30E+02  | -3.23E+03                                   | -6.18E+03                         | -2.57E+02              | -1.46E+02  |  |

Table 4. Radiative transition parameters for N<sub>2</sub> W <sup>3</sup>Δ<sub>u</sub>-B <sup>3</sup>Π<sub>g</sub>. For each v'-v'' band, the listed quantities are  $\lambda_{v'v''}$  (μm),  $\nu_{v'v''}$  (cm<sup>-1</sup>),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  (Å),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  (s<sup>-1</sup>) calculated by the r-centroid method, and  $A_{v'v''}$  (s<sup>-1</sup>) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| V'\V''      | 0           | 1         | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9        | 10      |
|-------------|-------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|---------|
| 16          | .4798       | .5225     | .5727     | .6323     | .7044     | .7932     | .9052     | 1.0509    | 1.2478    | 1.5286   | 1.9612  |
|             | 20843.8     | 19138.5   | 17462.2   | 15814.9   | 14196.6   | 12607.3   | 11047.1   | 9516.0    | 8014.2    | 6541.8   | 5098.9  |
| 6.87E-09    | 2.66E-07    | 4.72E-06  | 5.10E-05  | 3.77E-04  | 2.00E-03  | 7.76E-03  | 2.20E-02  | 4.39E-02  | 5.70E-02  | 3.84E-02 |         |
|             | .8856       | .9094     | .9311     | .9526     | .9747     | .9977     | 1.0219    | 1.0473    | 1.0744    | 1.1039   | 1.1379  |
| 3.44E-01    | 3.44E-01    | 3.44E-01  | 3.43E-01  | 3.41E-01  | 3.39E-01  | 3.37E-01  | 3.33E-01  | 3.29E-01  | 3.24E-01  | 3.17E-01 |         |
| 1.49E-02    | 4.48E-01    | 6.01E+00  | 4.80E+01  | 2.54E+02  | 9.34E+02  | 2.40E+03  | 4.26E+03  | 4.96E+03  | 3.39E+03  | 1.03E+03 |         |
| 1.54E-02*   | 4.60E-01*   | 6.16E+00* | 4.91E+01* | 2.60E+02* | 9.51E+02* | 2.44E+03* | 4.31E+03  | 4.99E+03  | 3.39E+03  | 1.02E+03 |         |
| 17          | .4559       | .4943     | .5390     | .5915     | .6541     | .7300     | .8238     | .9427     | 1.0982    | 1.3100   | 1.6153  |
|             | 21935.6     | 20230.3   | 18554.0   | 16906.7   | 15288.4   | 13699.2   | 12138.9   | 10607.9   | 9106.0    | 7633.6   | 6190.7  |
| 2.03E-09    | 8.68E-08    | 1.66E-06  | 1.93E-05  | 1.54E-04  | 8.92E-04  | 3.84E-03  | 1.24E-02  | 2.92E-02  | 4.87E-02  | 5.10E-02 |         |
|             | .8628       | .8917     | .9153     | .9373     | .9591     | .9815     | 1.0047    | 1.0290    | 1.0566    | 1.0819   | 1.1120  |
| 3.43E-01    | 3.44E-01    | 3.44E-01  | 3.43E-01  | 3.42E-01  | 3.41E-01  | 3.39E-01  | 3.36E-01  | 3.32E-01  | 3.28E-01  | 3.22E-01 |         |
| 5.13E-03    | 1.72E-01    | 2.54E+00  | 2.23E+01  | 1.31E+02  | 5.39E+02  | 1.59E+03  | 3.37E+03  | 4.94E+03  | 4.72E+03  | 2.54E+03 |         |
| 5.35E-03*   | 1.78E-01*   | 2.61E+00* | 2.29E+01* | 1.34E+02* | 5.50E+02* | 1.62E+03* | 3.41E+03  | 4.98E+03  | 4.73E+03  | 2.53E+03 |         |
| 18          | .4347       | .4695     | .5096     | .5564     | .6114     | .6772     | .7572     | .8565     | .9830     | 1.1493   | 1.3778  |
|             | 23002.9     | 21297.6   | 19621.3   | 17974.1   | 16355.8   | 14766.5   | 13206.3   | 11675.2   | 10173.4   | 8700.9   | 7258.0  |
| 5.63E-10    | 2.74E-08    | 5.76E-07  | 7.24E-06  | 6.23E-05  | 3.90E-04  | 1.84E-03  | 6.59E-03  | 1.79E-02  | 3.58E-02  | 4.98E-02 |         |
|             | .8298       | .8698     | .8978     | .9214     | .9436     | .9657     | .9883     | 1.0117    | 1.0361    | 1.0619   | 1.0896  |
| 3.42E-01    | 3.44E-01    | 3.44E-01  | 3.44E-01  | 3.43E-01  | 3.42E-01  | 3.40E-01  | 3.38E-01  | 3.35E-01  | 3.31E-01  | 3.27E-01 |         |
| 1.62E-03    | 6.33E-02    | 1.04E+00  | 1.01E+01  | 6.49E+01  | 2.97E+02  | 9.92E+02  | 2.42E+03  | 4.28E+03  | 5.24E+03  | 4.11E+03 |         |
| 1.72E-03*   | 6.59E-02*   | 1.08E+00* | 1.03E+01* | 6.65E+01* | 3.04E+02* | 1.01E+03* | 2.46E+03* | 4.33E+03  | 5.28E+03  | 4.12E+03 |         |
| 19          | .4159       | .4476     | .4839     | .5259     | .5748     | .6325     | .7018     | .7863     | .8916     | 1.0263   | 1.2047  |
|             | 24045.6     | 22340.3   | 20664.0   | 19016.8   | 17398.5   | 15809.2   | 14249.0   | 12717.9   | 11216.1   | 9743.6   | 8300.7  |
| 1.36E-10    | 8.13E-09    | 1.93E-07  | 2.66E-06  | 2.48E-05  | 1.67E-04  | 8.57E-04  | 3.38E-03  | 1.03E-02  | 2.38E-02  | 4.07E-02 |         |
|             | .7738       | .8392     | .8765     | .9040     | .9277     | .9502     | .9725     | .9952     | 1.0187    | 1.0433   | 1.0693  |
| 3.36E-01    | 3.42E-01    | 3.44E-01  | 3.44E-01  | 3.44E-01  | 3.43E-01  | 3.41E-01  | 3.40E-01  | 3.37E-01  | 3.34E-01  | 3.30E-01 |         |
| ( 4.31E-04) | 2.15E-02    | 4.08E-01  | 4.39E+00  | 3.12E+01  | 1.58E+02  | 5.86E+02  | 1.62E+03  | 3.34E+03  | 4.98E+03  | 5.13E+03 |         |
| 4.81E-04*   | 2.27E-02*   | 4.24E-01* | 4.53E+00* | 3.20E+01* | 1.61E+02* | 5.98E+02* | 1.65E+03* | 3.39E+03  | 5.03E+03  | 5.16E+03 |         |
| 20          | .3990       | .4281     | .4612     | .4991     | .5430     | .5943     | .6550     | .7280     | .8174     | .9292    | 1.0731  |
|             | 25063.6     | 23358.2   | 21682.0   | 20034.7   | 18416.4   | 16827.1   | 15266.9   | 13735.8   | 12234.0   | 10761.6  | 9318.7  |
| 2.36E-11    | 2.13E-09    | 6.11E-08  | 9.47E-07  | 9.64E-06  | 7.06E-05  | 3.91E-04  | 1.68E-03  | 5.64E-03  | 1.48E-02  | 2.95E-02 |         |
|             | .6471       | .7892     | .8477     | .8834     | .9105     | .9343     | .9569     | .9793     | 1.0022    | 1.0259   | 1.0506  |
| 3.14E-01    | 3.38E-01    | 3.43E-01  | 3.44E-01  | 3.44E-01  | 3.43E-01  | 3.42E-01  | 3.41E-01  | 3.39E-01  | 3.36E-01  | 3.33E-01 |         |
| ( 7.41E-05) | 6.27E-03    | 1.48E-01  | 1.83E+00  | 1.44E+01  | 8.04E+01  | 3.30E+02  | 1.02E+03  | 2.40E+03  | 4.21E+03  | 5.36E+03 |         |
| 9.84E-05*   | 6.90E-03*   | 1.56E-01* | 1.89E+00* | 1.49E+01* | 8.25E+01* | 3.38E+02* | 1.04E+03* | 2.44E+03* | 4.27E+03  | 5.40E+03 |         |
| 21          | .3838       | .4107     | .4410     | .4756     | .5152     | .5612     | .6150     | .6789     | .7560     | .8507    | .9698   |
|             | 26056.6     | 24351.3   | 22675.0   | 21027.7   | 19409.4   | 17820.1   | 16259.9   | 14728.8   | 13227.0   | 11754.6  | 10311.7 |
| 1.27E-12    | 4.23E-10    | 1.73E-08  | 3.19E-07  | 3.63E-06  | 2.91E-05  | 1.74E-04  | 8.12E-04  | 2.98E-03  | 8.66E-03  | 1.97E-02 |         |
|             | .0136       | .6835     | .8025     | .8563     | .8905     | .9173     | .9410     | .9637     | .9863     | 1.0094   | 1.0332  |
| 1.10E-01    | 3.21E-01    | 3.39E-01  | 3.43E-01  | 3.44E-01  | 3.44E-01  | 3.43E-01  | 3.42E-01  | 3.40E-01  | 3.38E-01  | 3.35E-01 |         |
| ( 5.54E-07) | ( 1.28E-03) | 4.69E-02  | 7.07E-01  | 6.37E+00  | 3.94E+01  | 1.79E+02  | 6.15E+02  | 1.62E+03  | 3.26E+03  | 4.92E+03 |         |
| 7.13E-06*   | 1.60E-03*   | 5.11E-02* | 7.43E-01* | 6.60E+00* | 4.06E+01* | 1.83E+02* | 6.28E+02* | 1.65E+03* | 3.30E+03* | 4.97E+03 |         |

Table 4. Radiative transition parameters for  $N_2 W^3\Delta_u - B^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \setminus V''$ | 11          | 12          | 13          | 14          | 15         | 16          | 17          | 18          | 19          | 20          | 21      |
|--------------------|-------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|---------|
| 16                 | 2.7132      | 4.3431      | 10.5325     | -26.7994    | -6.0061    | -3.4179     | -2.4067     | -1.8682     | -1.5342     | -1.3071     | -1.1428 |
|                    | 3685.7      | 2302.5      | 949.4       | -373.1      | -1665.0    | -2925.8     | -4155.1     | -5352.7     | -6518.0     | -7650.8     | -8750.4 |
| 4.06E-03           | 1.31E-02    | 5.23E-02    | 2.77E-02    | 4.27E-03    | 7.02E-02   | 2.83E-02    | 4.00E-02    | 2.00E-01    | 3.51E-01    | 3.67E-02    |         |
|                    | 1.2003      | 1.1690      | 1.2235      | 1.2831      | 1.2084     | 1.3367      | 1.4407      | 1.3539      | 1.6311      | 1.6953      | 1.9452  |
| 3.02E-01           | 3.10E-01    | 2.96E-01    | 2.78E-01    | 3.00E-01    | 2.61E-01   | 2.25E-01    | 2.55E-01    | 1.58E-01    | 1.37E-01    | 7.06E-02    |         |
| 3.76E+01           | 3.10E+01    | 7.92E+00    | -2.25E-01   | -3.58E+00   | -2.43E+02  | -2.08E+02   | -8.09E+02   | -2.81E+03   | -6.01E+03   | (-2.48E+02) |         |
| 3.49E+01*          | 3.22E+01    | 7.93E+00    | -2.19E-01   | -3.90E+00*  | -2.42E+02  | -2.01E+02   | -7.99E+02   | -2.91E+03   | -6.11E+03   | -1.56E+02   |         |
| 17                 | 2.0931      | 2.9461      | 4.8989      | 13.9141     | -17.4475   | -5.4528     | -3.2645     | -2.3470     | -1.8429     | -1.5246     | -1.3057 |
|                    | 4777.5      | 3394.3      | 2041.3      | 718.7       | -573.1     | -1833.9     | -3063.3     | -4260.8     | -5426.2     | -6559.0     | -7658.6 |
| 2.40E-02           | 7.61E-05    | 2.35E-02    | 5.02E-02    | 1.48E-02    | 1.18E-02   | 6.95E-02    | 1.68E-02    | 4.57E-02    | 1.95E-01    | 3.67E-01    |         |
|                    | 1.1485      | 1.4673      | 1.1842      | 1.2338      | 1.3033     | 1.2529      | 1.3464      | 1.4642      | 1.3577      | 1.6540      | 1.7130  |
| 3.15E-01           | 2.16E-01    | 3.06E-01    | 2.93E-01    | 2.72E-01    | 2.87E-01   | 2.58E-01    | 2.17E-01    | 2.54E-01    | 1.51E-01    | 1.32E-01    |         |
| 5.24E+02           | ( 2.81E-01) | 3.78E+01    | 3.23E+00    | -4.17E-01   | -1.22E+01  | -2.69E+02   | -1.24E+02   | -9.53E+02   | -2.54E+03   | -5.82E+03   |         |
| 5.12E+02           | 1.41E-01*   | 3.87E+01    | 3.22E+00    | -4.00E-01   | -1.27E+01  | -2.68E+02   | -1.18E+02   | -9.35E+02   | -2.65E+03   | -5.93E+03   |         |
| 18                 | 1.7109      | 2.2413      | 3.2169      | 5.5990      | 20.2357    | -13.0447    | -5.0101     | -3.1313     | -2.2942     | -1.8210     | -1.5172 |
|                    | 5844.9      | 4461.6      | 3108.6      | 1786.0      | 494.2      | -766.6      | -1996.0     | -3193.5     | -4358.9     | -5491.6     | -6591.3 |
| 4.14E-02           | 1.20E-02    | 1.73E-03    | 3.23E-02    | 4.34E-02    | 5.78E-03   | 2.06E-02    | 6.52E-02    | 8.84E-03    | 4.84E-02    | 1.97E-01    |         |
|                    | 1.1205      | 1.1621      | 1.1120      | 1.1959      | 1.2445     | 1.3384      | 1.2740      | 1.3559      | 1.4964      | 1.3543      | 1.6780  |
| 3.21E-01           | 3.11E-01    | 3.22E-01    | 3.03E-01    | 2.90E-01    | 2.60E-01   | 2.81E-01    | 2.54E-01    | 2.05E-01    | 2.55E-01    | 1.43E-01    |         |
| 1.72E+03           | 2.09E+02    | ( 1.09E+01) | 3.42E+01    | 8.90E-01    | -3.58E-01  | -2.62E+01   | -2.79E+02   | -6.26E+01   | -1.06E+03   | -2.34E+03   |         |
| 1.70E+03           | 2.01E+02    | 1.22E+01*   | 3.47E+01    | 8.82E-01    | -3.34E-01* | -2.69E+01   | -2.76E+02   | -5.83E+01*  | -1.03E+03   | -2.47E+03   |         |
| 19                 | 1.4519      | 1.8167      | 2.4089      | 3.5352      | 6.5067     | 36.2190     | -10.4903    | -4.6494     | -3.0155     | -2.2477     | -1.8023 |
|                    | 6887.6      | 5504.3      | 4151.3      | 2828.7      | 1536.9     | 276.1       | -953.3      | -2150.8     | -3316.2     | -4448.9     | -5548.6 |
| 4.71E-02           | 3.01E-02    | 3.89E-03    | 7.22E-03    | 3.79E-02    | 3.41E-02   | 1.03E-03    | 2.89E-02    | 5.85E-02    | 3.81E-03    | 4.77E-02    |         |
|                    | 1.0974      | 1.1296      | 1.1851      | 1.1523      | 1.2063     | 1.2561      | 1.4453      | 1.2883      | 1.3656      | 1.5459      | 1.3404  |
| 3.25E-01           | 3.19E-01    | 3.06E-01    | 3.14E-01    | 3.00E-01    | 2.86E-01   | 2.24E-01    | 2.76E-01    | 2.51E-01    | 1.88E-01    | 2.60E-01    |         |
| 3.30E+03           | 1.03E+03    | 5.27E+01    | 3.26E+01    | 2.51E+01    | 1.19E-01   | (-9.05E-02) | -4.44E+01   | -2.73E+02   | (-2.40E+01) | -1.11E+03   |         |
| 3.29E+03           | 1.02E+03    | 4.90E+01*   | 3.43E+01*   | 2.53E+01    | 1.17E-01   | -7.62E-02*  | -4.52E+01   | -2.70E+02   | -2.12E+01*  | -1.07E+03   |         |
| 20                 | 1.2649      | 1.5332      | 1.9345      | 2.5997      | 3.9142     | 7.7278      | 154.6312    | -8.8270     | -4.3511     | -2.9146     | -2.2072 |
|                    | 7905.5      | 6522.3      | 5169.2      | 3846.6      | 2554.8     | 1294.0      | 64.7        | -1132.9     | -2298.3     | -3431.0     | -4530.7 |
| 4.30E-02           | 4.12E-02    | 1.91E-02    | 2.74E-04    | 1.44E-02    | 3.95E-02   | 2.41E-02    | 6.86E-05    | 3.53E-02    | 5.08E-02    | 1.07E-03    |         |
|                    | 1.0769      | 1.1055      | 1.1399      | 1.2905      | 1.1697     | 1.2164      | 1.2694      | .6154       | 1.2993      | 1.3761      | 1.6392  |
| 3.29E-01           | 3.24E-01    | 3.16E-01    | 2.76E-01    | 3.10E-01    | 2.98E-01   | 2.82E-01    | 3.06E-01    | 2.73E-01    | 2.48E-01    | 1.56E-01    |         |
| 4.65E+03           | 2.42E+03    | 5.34E+02    | ( 2.40E+00) | 4.66E+01    | 1.54E+01   | 1.05E-03    | (-1.89E-02) | -6.48E+01   | -2.55E+02   | (-4.88E+00) |         |
| 4.66E+03           | 2.41E+03    | 5.21E+02    | 1.78E+00*   | 4.81E+01    | 1.54E+01   | 1.03E-03    | -6.59E-02*  | -6.55E+01   | -2.51E+02   | -3.46E+00*  |         |
| 21                 | 1.1238      | 1.3306      | 1.6228      | 2.0663      | 2.8186     | 4.3725      | 9.4547      | -71.4868    | -7.6613     | -4.1017     | -2.8267 |
|                    | 8898.5      | 7515.3      | 6162.2      | 4839.6      | 3547.8     | 2287.0      | 1057.7      | -139.9      | -1305.3     | -2438.0     | -3537.7 |
| 3.41E-02           | 4.24E-02    | 3.30E-02    | 9.08E-03    | 6.70E-04    | 2.13E-02   | 3.76E-02    | 1.51E-02    | 1.94E-03    | 3.95E-02    | 4.32E-02    |         |
|                    | 1.0580      | 1.0845      | 1.1139      | 1.1526      | 1.0807     | 1.1821      | 1.2264      | 1.2860      | 1.1643      | 1.3081      | 1.3889  |
| 3.32E-01           | 3.27E-01    | 3.22E-01    | 3.14E-01    | 3.28E-01    | 3.07E-01   | 2.95E-01    | 2.77E-01    | 3.11E-01    | 2.70E-01    | 2.43E-01    |         |
| 5.36E+03           | 3.91E+03    | 1.62E+03    | 2.23E+02    | ( 6.53E+00) | 4.86E+01   | 7.82E+00    | -6.43E-03   | (-8.46E-01) | -8.48E+01   | -2.29E+02   |         |
| 5.39E+03           | 3.91E+03    | 1.60E+03    | 2.14E+02*   | 7.79E+00*   | 4.96E+01   | 7.80E+00    | -6.22E-03   | -9.54E-01*  | -8.53E+01   | -2.25E+02   |         |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 5. Radiative transition parameters for N<sub>2</sub> B' <sup>3</sup>Sigma- B <sup>3</sup>Pi<sub>g</sub>. For each v'-v'' band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the r-centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| V'\V'' | 0   | 1   | 2  | 3   | 4   | 5   | 6   | 7  | 8   | 9   | 10  |
|--------|---|---|--|---|---|---|---|--|---|---|---|
| 0      | 1.5280<br>6544.5<br>4.81E-01<br>1.2498<br>1.75E-01<br>1.68E+04<br>1.67E+04  | 2.0664<br>4839.2<br>3.84E-01<br>1.2983<br>1.56E-01<br>3.65E+02<br>4.90E+03  | 3.1616<br>3163.0<br>1.17E-01<br>1.3542<br>1.42E-01<br>4.87E+00<br>3.66E+02 | 6.5977<br>1515.7<br>1.71E-02<br>1.4215<br>1.5083<br>-4.10E-05<br>4.92E+00   | -97.4459<br>-102.6<br>1.22E-03<br>1.5083<br>1.6375<br>-3.44E-03<br>-4.13E-05* | -5.9105<br>-1691.9<br>3.72E-05<br>1.5083<br>1.9315<br>(-4.35E-05)<br>-3.36E-03* | -3.0749<br>-3252.1<br>2.83E-07<br>1.24E-01<br>1.4620<br>4.69E-02<br>-1.96E-05*    | -2.0907<br>-4783.2<br>4.27E-10<br>9.72E-02<br>1.7599<br>1.59E-01<br>-1.08E-05*     | -1.5911<br>-6285.0<br>6.55E-11<br>2.11E-14<br>1.7599<br>7.39E-02<br>-1.01E-07*  | -1.2891<br>-7757.4<br>2.11E-14<br>3.16E-14<br>-1.4747<br>7.75E-05<br>-1.24E-08* | -1.0869<br>-9200.3<br>3.16E-14<br>1.6706<br>9.06E-02<br>-2.10E-16<br>-2.16E-10* |
| 1      | 1.2442<br>8037.2<br>3.20E-01<br>1.2074<br>1.82E-01<br>2.24E+04<br>2.24E+04  | 1.5793<br>6331.9<br>3.57E-02<br>1.2732<br>1.65E-01<br>1.08E+03<br>1.05E+03  | 2.1479<br>4655.6<br>3.55E-01<br>1.3083<br>1.54E-01<br>6.08E+02<br>3.93E+03 | 3.3241<br>3008.3<br>2.32E-01<br>1.4360<br>1.40E-01<br>1.12E+01<br>6.11E+02  | 7.1941<br>1390.0<br>5.24E-02<br>1.4303<br>1.22E-01<br>-1.19E-03<br>1.13E+01   | -50.1875<br>-199.3<br>5.00E-03<br>1.5182<br>9.44E-02<br>-1.82E-02<br>-1.20E-03* | -5.6835<br>-1759.5<br>1.85E-04<br>1.6516<br>9.44E-02<br>(-1.75E-04)<br>-1.76E-02* | -3.0390<br>-3290.5<br>1.46E-06<br>1.9797<br>4.07E-02<br>2.07E-01<br>-4.87E-05*     | -2.0867<br>-4792.4<br>6.03E-09<br>.8399<br>6.26E-02<br>1.35E-01<br>-8.85E-05*   | -1.5962<br>-6264.8<br>5.38E-10<br>1.8265<br>1.35E-01<br>-1.05E-06<br>-1.53E-07* | -1.2974<br>-7707.7<br>1.18E-12<br>.3426<br>1.35E-01<br>-1.99E-08                |
| 2      | 1.0520<br>9505.8<br>1.34E-01<br>1.1706<br>1.08E-01<br>1.64E+04<br>1.65E+04  | 1.2820<br>7800.5<br>2.21E-01<br>1.2170<br>1.81E-01<br>4.39E+04<br>5.138E+04 | 1.6329<br>6124.3<br>1.66E-02<br>1.2285<br>1.79E-01<br>2.05E+03<br>5.12E+02 | 2.2337<br>4477.0<br>2.14E-01<br>1.3205<br>1.62E-01<br>6.61E+02<br>2.04E+03  | 3.4981<br>2858.7<br>3.01E-01<br>1.3724<br>1.52E-01<br>1.59E+01<br>6.63E+02    | 7.8778<br>1269.4<br>1.00E-01<br>1.4394<br>1.38E-01<br>1.20E-01<br>1.60E+01      | -34.3849<br>-290.8<br>1.23E-02<br>1.5284<br>-8.79E-03<br>-5.47E-02<br>-8.83E-03   | -5.4888<br>-1821.9<br>5.34E-04<br>1.6666<br>-5.47E-02<br>(-3.52E-04)<br>-5.28E-02* | -3.0087<br>-3323.7<br>4.16E-06<br>2.0398<br>-3.54E-02<br>-2.50E-05*             | -2.0850<br>-4796.2<br>4.05E-08<br>1.0630<br>5.11E-02<br>-3.96E-04*              | -1.6028<br>-6239.0<br>2.35E-09<br>1.9018<br>5.11E-02<br>-6.82E-07*              |
| 3      | .9132<br>10950.7<br>4.57E-02<br>1.1379<br>1.92E-01<br>8.99E+03<br>9.06E+03  | 1.0816<br>9245.4<br>1.93E-01<br>1.1784<br>1.78E-01<br>2.15E+04<br>2.15E+04  | 1.3212<br>7569.1<br>8.12E-02<br>1.2302<br>1.79E-01<br>4.55E+03<br>4.49E+03 | 1.6887<br>5921.8<br>9.44E-02<br>1.2555<br>1.74E-01<br>2.41E+03<br>2.44E+03  | 2.3237<br>4303.5<br>8.94E-02<br>1.3379<br>1.59E-01<br>7.30E+02<br>7.19E+02    | 3.6843<br>2714.2<br>3.19E-01<br>1.3823<br>1.50E-01<br>5.84E+02<br>5.84E+02      | 8.6653<br>1154.0<br>1.53E-01<br>1.4488<br>1.37E-01<br>1.78E+01<br>1.79E+01        | -26.5222<br>-377.0<br>2.35E-02<br>1.5388<br>1.18E-01<br>-3.53E-02<br>-3.54E-02     | -5.3224<br>-1878.9<br>1.17E-03<br>1.6825<br>8.83E-02<br>-1.22E-01<br>-1.17E-01* | -2.9839<br>-3351.3<br>8.42E-06<br>2.1182<br>2.61E-02<br>1.81E-01<br>-3.33E-03   | -2.0859<br>-4794.2<br>1.82E-07<br>1.2145<br>1.81E-01<br>-1.33E-03<br>-1.27E-03* |
| 4      | .8083<br>12372.0<br>1.40E-02<br>1.1085<br>1.96E-01<br>4.13E+03<br>4.17E+03  | .9375<br>8990.4<br>1.01E-01<br>1.1451<br>1.81E-01<br>1.82E+04<br>1.83E+04   | 1.1123<br>7343.1<br>9.15E-03<br>1.1870<br>1.85E-01<br>1.69E+04<br>1.69E+04 | 1.3618<br>5724.8<br>1.48E-01<br>1.2656<br>1.73E-01<br>4.37E+02<br>4.15E+02* | 1.7468<br>4135.5<br>1.91E-02<br>1.2675<br>1.72E-01<br>3.34E+03<br>3.35E+03    | 2.4181<br>2575.3<br>2.96E-01<br>1.3767<br>1.51E-01<br>1.25E+02<br>1.21E+02      | 3.8831<br>1044.2<br>2.04E-01<br>1.3931<br>1.48E-01<br>4.50E+02<br>4.49E+02        | 9.5765<br>-457.6<br>3.85E-02<br>1.4584<br>1.34E-01<br>1.70E+01<br>1.71E+01         | -21.8531<br>-1930.0<br>2.14E-03<br>1.5496<br>8.50E-02<br>-9.94E-02<br>-9.97E-02 | -5.1812<br>-3372.9<br>1.33E-05<br>1.6995<br>2.2268<br>8.50E-02<br>-2.25E-01     | -2.9648<br>-1.2145<br>1.33E-05<br>1.6995<br>2.2268<br>1.77E-02<br>(-3.23E-04)   |
| 5      | .7262<br>13769.8<br>4.06E-03<br>1.0817<br>1.99E-01<br>1.70E+03<br>1.72E+03* | .8289<br>12064.5<br>4.22E-02<br>1.1154<br>1.95E-01<br>1.90E-01<br>2.20E+04  | .9626<br>10388.2<br>1.34E-01<br>1.1526<br>1.84E-01<br>1.84E+03<br>9.43E+03 | 1.1440<br>8740.9<br>1.04E-01<br>1.1969<br>1.88E-01<br>2.18E+02<br>2.36E+02* | 1.4040<br>7122.6<br>4.21E-03<br>1.5534<br>1.55E-01<br>1.76E-01<br>3.05E+03    | 1.8072<br>5533.4<br>1.55E-01<br>1.2782<br>1.70E-01<br>7.65E-03<br>1.76E+00*     | 2.5169<br>3973.1<br>1.62E-05<br>-.6362<br>7.65E-03<br>1.46E-01<br>3.11E+02        | 4.0949<br>2442.1<br>2.50E-01<br>1.4051<br>1.46E-01<br>1.47E+01<br>1.47E+01         | 10.6355<br>940.2<br>2.48E-01<br>1.4685<br>1.32E-01<br>1.47E+01<br>1.47E+01      | -18.7903<br>-532.2<br>5.68E-02<br>1.5608<br>1.13E-01<br>1.47E+01<br>1.47E+01    | -5.0631<br>-1975.1<br>3.45E-03<br>1.7179<br>8.16E-02<br>1.86E-01<br>-3.37E-01*  |
| 6      | .6603<br>15144.4<br>1.14E-03<br>1.0571<br>2.01E-01<br>6.48E+02<br>6.58E+02* | .7441<br>13439.1<br>1.55E-02<br>1.0884<br>1.98E-01<br>1.84E+04<br>1.85E+04  | .8501<br>11762.8<br>7.40E-02<br>1.1224<br>1.89E-01<br>2.00E+04<br>1.99E+04 | .9886<br>10115.5<br>1.33E-01<br>1.1604<br>1.82E-01<br>3.62E+03<br>3.55E+03  | 1.1769<br>8497.2<br>4.41E-02<br>1.2105<br>1.81E-01<br>1.49E+03<br>1.53E+03    | 1.4476<br>6908.0<br>3.43E-02<br>1.2180<br>1.81E-01<br>1.68E-01<br>1.53E+03      | 1.8699<br>5347.7<br>1.24E-01<br>1.2894<br>1.72E-01<br>2.18E+03<br>2.16E+03        | 2.6201<br>3816.7<br>1.46E-02<br>1.2703<br>1.4189<br>1.97E+02<br>1.97E+02           | 4.3199<br>2314.9<br>1.93E-01<br>1.4789<br>1.4789<br>1.47E+01<br>1.47E+01        | 11.8707<br>842.4<br>2.84E-01<br>1.4789<br>1.4789<br>1.47E+01<br>1.47E+01        | -16.6533<br>-600.5<br>7.75E-02<br>1.5723<br>1.11E-01<br>-4.15E-01<br>-4.16E-01  |
| 7      | .6062<br>16495.9<br>3.16E-04<br>1.0344<br>2.03E-01<br>2.36E+02<br>2.40E+02* | .6761<br>14790.6<br>5.26E-03<br>1.0637<br>2.00E-01<br>2.77E+03<br>2.81E+03* | .7625<br>13114.3<br>3.37E-02<br>1.0529<br>1.97E-01<br>1.93E-01<br>2.12E+04 | .8721<br>11467.0<br>9.72E-02<br>1.1296<br>1.88E-01<br>1.88E-01<br>2.23E+04  | 1.0154<br>9848.7<br>1.06E-01<br>1.1690<br>1.77E-01<br>1.44E+04<br>1.44E+04    | 1.2107<br>8259.5<br>8.54E-03<br>1.2407<br>1.78E-01<br>6.10E+02<br>5.78E+02*     | 1.4927<br>6699.2<br>6.95E-02<br>1.2329<br>1.78E-01<br>2.69E+03<br>2.72E+03        | 1.9349<br>5168.2<br>8.15E-02<br>1.3025<br>1.66E-01<br>1.25E+03<br>1.24E+03         | 2.7275<br>3666.4<br>4.45E-02<br>1.3065<br>1.65E-01<br>2.42E+02<br>2.47E+02      | 4.5581<br>2193.9<br>1.38E-01<br>1.4355<br>1.39E-01<br>1.15E+02<br>1.13E+02      | 13.3152<br>751.0<br>3.09E-01<br>1.4899<br>1.28E-01<br>8.67E+00<br>8.70E+00      |

## TRANSITION PROBABILITIES AND RELATED DATA FOR NITROGEN AND OXYGEN BANDS 1041

Table 5. Radiative transition parameters for  $N_2 B' ^3\Sigma_u^- - B ^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 11          | 12          | 13          | 14          | 15          | 16          | 17          | 18          | 19          | 20          | 21       |
|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----------|
| 0                   | -.9422      | -.8336      | -.7491      | -.6816      | -.6264      | -.5806      | -.5419      | -.5089      | -.4804      | -.4556      | -.4338   |
|                     | -10613.5    | -11996.7    | -13349.8    | -14672.4    | -15964.2    | -17225.0    | -18454.3    | -19651.9    | -20817.3    | -21950.0    | -23049.7 |
| 1.57E-16            | 4.06E-16    | 4.26E-16    | 1.35E-16    | 1.85E-16    | 1.80E-16    | 3.85E-16    | 2.81E-16    | 2.93E-17    | 8.80E-17    | 4.23E-16    |          |
|                     | .6392       | 1.3247      | 1.1838      | 1.2125      | .4912       | 1.1217      | 1.1830      | 1.2364      | 1.4039      | 1.1080      | 1.1938   |
| 1.89E-01            | 1.62E-01    | 1.86E-01    | 1.82E-01    | 1.65E-01    | 1.94E-01    | 1.86E-01    | 1.78E-01    | 1.46E-01    | 1.96E-01    | 1.84E-01    |          |
| (-1.36E-11)         | -3.71E-11   | -7.09E-11   | -2.85E-11   | (-4.13E-13) | -7.02E-11   | -1.70E-10   | -1.36E-10   | -1.14E-11   | -7.23E-11   | -3.57E-10   |          |
| -3.22E-11*          | -3.45E-11*  | -7.23E-11*  | -2.93E-11*  | -1.28E-12*  | -7.16E-11*  | -1.70E-10*  | -1.36E-10*  | -1.20E-11*  | -7.43E-11*  | -3.57E-10*  |          |
| 1                   | -1.0964     | -.9520      | -.8434      | -.7587      | -.6910      | -.6356      | -.5896      | -.5507      | -.5175      | -.4888      | -.4639   |
|                     | -9120.9     | -10504.1    | -11857.1    | -13179.7    | -14471.6    | -15732.3    | -16961.7    | -18159.2    | -19324.6    | -20457.4    | -21557.0 |
| 2.59E-13            | 5.62E-16    | 3.86E-15    | 9.24E-16    | 2.83E-16    | 2.34E-15    | 2.48E-15    | 6.07E-16    | 1.18E-16    | 1.47E-15    | 2.17E-15    |          |
| 1.8395              | .6122       | 1.4212      | 1.3088      | 1.1227      | 1.1911      | 1.2091      | 1.2376      | 1.1261      | 1.1916      | 1.2025      |          |
| 6.05E-02            | 1.85E-01    | 1.42E-01    | 1.65E-01    | 1.94E-01    | 1.85E-01    | 1.82E-01    | 1.77E-01    | 1.94E-01    | 1.85E-01    | 1.83E-01    |          |
| (-1.46E-09)         | (-4.53E-11) | -2.64E-10   | -1.16E-10   | -6.55E-11   | -6.30E-10   | -8.13E-10   | -2.32E-10   | -6.48E-11   | -8.69E-10   | -1.48E-09   |          |
| -2.67E-10*          | -9.68E-11*  | -2.47E-10*  | -1.21E-10*  | -6.27E-11*  | -6.24E-10*  | -8.10E-10*  | -2.31E-10*  | -6.56E-11*  | -8.66E-10*  | -1.47E-09*  |          |
| 2                   | -1.3068     | -1.1068     | -.9626      | -.8539      | -.7691      | -.7011      | -.6455      | -.5991      | -.5600      | -.5266      | -.4978   |
|                     | -7652.2     | -9035.4     | -10388.5    | -11711.1    | -13002.9    | -14263.7    | -15493.0    | -16690.6    | -17856.0    | -18988.7    | -20088.4 |
| 1.67E-11            | 1.15E-12    | 2.25E-14    | 4.26E-16    | 1.58E-15    | 5.14E-15    | 3.06E-15    | 1.59E-16    | 9.56E-16    | 3.19E-15    | 3.27E-15    |          |
| .8689               | 2.0223      | 1.1617      | 3.0134      | 1.0104      | 1.1914      | 1.2019      | 1.2372      | 1.1735      | 1.1830      | 1.1822      |          |
| 2.08E-01            | 3.57E-02    | 1.89E-01    | 4.01E-04    | 2.05E-01    | 1.85E-01    | 1.83E-01    | 1.77E-01    | 1.87E-01    | 1.86E-01    | 1.86E-01    |          |
| (-6.55E-07)         | (-2.20E-09) | (-1.83E-09) | (-2.22E-16) | -2.94E-10   | -1.03E-09   | -7.74E-10   | -4.71E-11   | -3.87E-10   | -1.53E-09   | -1.86E-09   |          |
| -9.80E-07*          | -5.42E-10*  | -1.44E-09*  | -5.28E-11*  | -3.23E-10*  | -9.95E-10*  | -7.58E-10*  | -4.62E-11*  | -3.87E-10*  | -1.52E-09*  | -1.84E-09*  |          |
| 3                   | -1.6110     | -1.3174     | -1.1181     | -.9741      | -.8652      | -.7801      | -.7118      | -.6559      | -.6093      | -.5700      | -.5364   |
|                     | -6207.4     | -7590.6     | -8943.6     | -10266.2    | -11558.1    | -12818.8    | -14048.2    | -15245.7    | -16411.1    | -17543.9    | -18643.5 |
| 7.05E-09            | 1.22E-10    | 4.20E-12    | 3.78E-13    | 6.92E-15    | 2.14E-15    | 5.72E-16    | 1.63E-16    | 1.74E-15    | 3.08E-15    | 2.89E-15    |          |
| 1.9936              | 1.1292      | 2.1613      | 1.3305      | .2516       | .7327       | 1.0612      | 1.1581      | 1.1346      | 1.1285      | 1.1211      |          |
| 3.90E-02            | 1.93E-01    | 2.24E-02    | 1.61E-01    | 1.16E-01    | 2.00E-01    | 2.01E-01    | 1.90E-01    | 1.93E-01    | 1.93E-01    | 1.94E-01    |          |
| (-5.20E-06)         | (-4.02E-06) | (-3.07E-09) | (-2.13E-08) | (-2.89E-10) | (-3.66E-10) | (-1.29E-10) | (-4.21E-11) | -5.79E-10   | -1.26E-09   | -1.43E-09   |          |
| -6.04E-08*          | -4.09E-06*  | -1.51E-08*  | -1.60E-08*  | -3.16E-09*  | -6.70E-10*  | -1.15E-10*  | -5.05E-11*  | -5.90E-10*  | -1.26E-09*  | -1.41E-09*  |          |
| 4                   | -2.0894     | -1.6209     | -1.3294     | -1.1306     | -.9865      | -.8774      | -.7920      | -.7234      | -.6671      | -.6202      | -.5806   |
|                     | -4786.1     | -6169.3     | -7522.4     | -8845.0     | -10136.8    | -11397.6    | -12626.9    | -13824.5    | -14989.9    | -16122.6    | -17222.3 |
| 6.23E-07            | 1.58E-08    | 6.01E-10    | 9.90E-12    | 1.91E-12    | 1.48E-14    | 2.31E-15    | 2.68E-15    | 2.74E-15    | 3.15E-15    | 3.78E-15    |          |
| 1.3276              | 2.1171      | 1.3002      | 2.4054      | 1.4546      | .0149       | 2.2855      | 1.2908      | 1.0640      | 1.0125      | 1.0123      |          |
| 1.61E-01            | 2.62E-02    | 1.66E-01    | 8.72E-03    | 1.35E-01    | 6.95E-02    | 1.42E-02    | 1.68E-01    | 2.00E-01    | 2.04E-01    | 2.04E-01    |          |
| (-3.59E-03)         | (-5.16E-06) | (-1.43E-05) | (-1.05E-09) | (-7.39E-08) | (-2.15E-10) | (-1.89E-12) | -4.05E-10   | (-7.52E-10) | -1.12E-09   | -1.64E-09   |          |
| -3.22E-03*          | -3.93E-06*  | -1.26E-05*  | -1.57E-07*  | -4.96E-08*  | -8.08E-09*  | -1.23E-11*  | -4.48E-10*  | -8.37E-10*  | -1.19E-09*  | -1.68E-09*  |          |
| 5                   | -2.9514     | -2.0958     | -1.6328     | -1.3428     | -1.1443     | -1.0000     | -.8905      | -.8047      | -.7357      | -.6791      | -.6319   |
|                     | -3388.3     | -4771.5     | -6124.5     | -7447.1     | -8738.9     | -9999.7     | -11229.1    | -12426.6    | -13592.0    | -14724.7    | -15824.4 |
| 1.66E-05            | 1.76E-06    | 2.72E-08    | 2.34E-09    | 1.18E-11    | 6.72E-12    | 6.74E-14    | 1.74E-14    | 1.32E-14    | 1.05E-14    | 1.45E-14    |          |
| 2.3913              | 1.4181      | 2.3000      | 1.4300      | 3.0719      | 1.5917      | .4101       | 1.9827      | 1.2386      | .9779       | .9687       |          |
| 9.25E-03            | 1.43E-01    | 1.34E-02    | 1.40E-01    | 2.82E-04    | 1.07E-01    | 1.49E-01    | 4.03E-02    | 1.77E-01    | 2.06E-01    | 2.07E-01    |          |
| (-1.12E-04)         | (-7.90E-03) | (-2.27E-06) | (-3.85E-05) | (-1.26E-12) | (-1.54E-07) | (-4.28E-09) | (-1.10E-10) | -2.12E-09   | (-2.90E-09) | -4.98E-09   |          |
| -5.22E-03*          | -6.87E-03*  | -4.99E-05*  | -3.13E-05*  | -1.10E-06*  | -8.43E-08*  | -2.20E-08*  | -1.17E-11*  | -2.05E-09*  | -3.31E-09*  | -5.42E-09*  |          |
| 6                   | -4.9661     | -2.9439     | -2.1053     | -1.6468     | -1.3579     | -1.1594     | -1.0148     | -.9048      | -.8185      | -.7491      | -.6921   |
|                     | -2013.6     | -3396.9     | -4749.9     | -6072.5     | -7364.3     | -8625.1     | -9854.5     | -11052.0    | -12217.4    | -13350.1    | -14449.8 |
| 5.06E-03            | 1.58E-05    | 4.25E-06    | 3.39E-08    | 7.43E-09    | 2.11E-12    | 2.01E-11    | 4.57E-13    | 5.99E-14    | 8.88E-14    | 9.05E-14    |          |
| 1.7578              | 2.6785      | 1.4952      | 2.6195      | 1.5382      | 7.7851      | 1.7316      | .9264       | 1.9274      | 1.2141      | 1.0253      |          |
| 7.79E-02            | 2.48E-03    | 1.27E-01    | 3.32E-03    | 1.18E-01    | 3.13E-30    | 7.90E-02    | 2.08E-01    | 4.75E-02    | 1.81E-01    | 2.04E-01    |          |
| -5.08E-01           | (-7.73E-06) | (-1.48E-02) | (-1.69E-07) | (-8.33E-05) | (0.00E+00)  | (-2.43E-07) | (-5.40E-08) | (-4.99E-10) | (-1.41E-08) | -2.29E-08   |          |
| -4.70E-01*          | -1.86E-02*  | -1.26E-02*  | -2.71E-04*  | -6.28E-05*  | -5.15E-06*  | -8.40E-08*  | -6.39E-08*  | -4.67E-11*  | -1.25E-08*  | -2.40E-08*  |          |
| 7                   | -15.1024    | -4.8891     | -2.9426     | -2.1182     | -1.6631     | -1.3748     | -1.1761     | -1.0309     | -.9203      | -.8334      | -.7635   |
|                     | -662.1      | -2045.4     | -3398.4     | -4721.0     | -6012.8     | -7273.6     | -8503.0     | -9700.5     | -10865.9    | -11998.6    | -13098.3 |
| 9.98E-02            | 6.86E-03    | 9.78E-06    | 9.06E-06    | 2.48E-08    | 1.99E-08    | 2.92E-11    | 4.76E-11    | 2.04E-12    | 2.54E-13    | 5.30E-13    |          |
| 1.5842              | 1.7597      | 3.3355      | 1.5643      | 3.4033      | 1.6374      | -1.0751     | 1.9032      | 1.2600      | 1.7283      | 1.2087      |          |
| 1.08E-01            | 7.39E-02    | 5.15E-05    | 1.12E-01    | 3.22E-05    | 9.72E-02    | 8.84E-04    | 5.09E-02    | 1.74E-01    | 7.96E-02    | 1.82E-01    |          |
| -6.86E-01           | (-6.50E-01) | (-2.06E-09) | (-2.43E-02) | (-1.14E-11) | (-1.46E-04) | (-2.84E-11) | (-2.28E-07) | (-1.60E-07) | (-5.64E-09) | (-8.00E-08) |          |
| -6.86E-01           | -5.90E-01*  | -5.10E-02*  | -2.02E-02*  | -1.01E-03*  | -9.91E-05*  | -1.84E-05*  | -4.05E-09*  | -1.23E-07*  | -2.50E-09*  | -6.85E-08*  |          |

Table 5. Radiative transition parameters for  $N_2$   $B'$   $^3\Sigma_u^-$ - $B$   $^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| $V' \setminus V''$ | 0         | 1         | 2         | 3         | 4         | 5           | 6         | 7           | 8         | 9           | 10      |
|--------------------|-----------|-----------|-----------|-----------|-----------|-------------|-----------|-------------|-----------|-------------|---------|
| 8                  | .5610     | .6204     | .6924     | .7815     | .8947     | 1.0430      | 1.2457    | 1.5392      | 2.0021    | 2.8389      | 4.8087  |
|                    | 17824.4   | 16119.1   | 14442.9   | 12795.6   | 11177.3   | 9588.0      | 8027.8    | 6496.7      | 4994.9    | 3522.4      | 2079.5  |
| 8.73E-05           | 1.71E-03  | 1.36E-02  | 5.44E-02  | 1.05E-01  | 6.80E-02  | 2.62E-04    | 9.24E-02  | 4.19E-02    | 7.55E-02  | 9.05E-02    |         |
|                    | 1.0135    | 1.0410    | 1.0704    | 1.1021    | 1.1371    | 1.1789      | .9752     | 1.2438      | 1.3202    | 1.3237      | 1.4569  |
| 2.04E-01           | 2.02E-01  | 2.00E-01  | 1.97E-01  | 1.92E-01  | 1.87E-01  | 2.06E-01    | 1.76E-01  | 1.63E-01    | 1.62E-01  | 1.35E-01    |         |
| 8.37E+01           | 1.19E+03  | 6.65E+03  | 1.78E+04  | 2.19E+04  | 8.46E+03  | ( 2.34E+01) | 3.19E+03  | 5.59E+02    | 3.50E+02  | 5.99E+01    |         |
| 8.52E+01*          | 1.21E+03* | 6.73E+03  | 1.80E+04  | 2.20E+04  | 8.36E+03  | 3.37E+01*   | 3.21E+03  | 5.45E+02    | 3.55E+02  | 5.92E+01    |         |
| 9                  | .5227     | .5739     | .6350     | .7092     | .8011     | .9180       | 1.0714    | 1.2817      | 1.5872    | 2.0712      | 2.9540  |
|                    | 19130.1   | 17424.8   | 15748.5   | 14101.2   | 12482.9   | 10893.6     | 9333.4    | 7802.4      | 6300.5    | 4828.1      | 3385.2  |
| 2.43E-05           | 5.45E-04  | 5.16E-03  | 2.60E-02  | 7.21E-02  | 9.62E-02  | 3.30E-02    | 1.16E-02  | 9.76E-02    | 1.45E-02  | 9.96E-02    |         |
|                    | .9942     | 1.0201    | 1.0477    | 1.0772    | 1.1092    | 1.1449      | 1.1919    | 1.1802      | 1.2538    | 1.3520      | 1.3361  |
| 2.06E-01           | 2.04E-01  | 2.02E-01  | 1.99E-01  | 1.96E-01  | 1.91E-01  | 1.85E-01    | 1.86E-01  | 1.75E-01    | 1.56E-01  | 1.59E-01    |         |
| 2.91E+01           | 4.86E+02  | 3.33E+03  | 1.17E+04  | 2.18E+04  | 1.85E+04  | 3.71E+03    | 7.75E+02  | 3.02E+03    | 1.62E+02  | 3.98E+02    |         |
| 2.97E+01*          | 4.95E+02* | 3.37E+03* | 1.19E+04  | 2.19E+04  | 1.84E+04  | 3.63E+03    | 8.11E+02  | 3.01E+03    | 1.54E+02  | 4.00E+02    |         |
| 10                 | .4899     | .5345     | .5872     | .6500     | .7264     | .8213       | .9419     | 1.1007      | 1.3187    | 1.6364      | 2.1422  |
|                    | 20413.0   | 18707.7   | 17031.4   | 15384.1   | 13765.8   | 12176.5     | 10616.3   | 9085.3      | 7583.4    | 6111.0      | 4668.1  |
| 6.87E-06           | 1.72E-04  | 1.87E-03  | 1.13E-02  | 4.05E-02  | 8.20E-02  | 7.59E-02    | 9.61E-03  | 3.17E-02    | 8.76E-02  | 1.58E-03    |         |
|                    | .9765     | 1.0007    | 1.0267    | 1.0544    | 1.0840    | 1.1164      | 1.1534    | 1.2154      | 1.2017    | 1.2640      | 1.4789  |
| 2.06E-01           | 2.05E-01  | 2.03E-01  | 2.01E-01  | 1.98E-01  | 1.95E-01  | 1.90E-01    | 1.81E-01  | 1.83E-01    | 1.73E-01  | 1.30E-01    |         |
| 1.01E+01           | 1.92E+02  | 1.55E+03  | 6.76E+03  | 1.69E+04  | 2.28E+04  | 1.33E+04    | 9.57E+02  | 1.88E+03    | 2.42E+03  | ( 1.10E+01) |         |
| 1.03E+01*          | 1.96E+02* | 1.57E+03* | 6.85E+03  | 1.70E+04  | 2.29E+04  | 1.32E+04    | 9.11E+02* | 1.92E+03    | 2.40E+03  | 9.35E+00*   |         |
| 11                 | .4614     | .5008     | .5467     | .6008     | .6655     | .7442       | .8420     | .9666       | 1.1308    | 1.3566      | 1.6868  |
|                    | 21673.2   | 19967.9   | 18291.6   | 16644.3   | 15026.0   | 13436.7     | 11876.5   | 10345.5     | 8843.6    | 7371.2      | 5928.3  |
| 1.98E-06           | 5.42E-05  | 6.60E-04  | 4.62E-03  | 2.01E-02  | 5.41E-02  | 8.22E-02    | 5.08E-02  | 2.92E-04    | 5.11E-02  | 6.85E-02    |         |
|                    | .9602     | .9829     | 1.0073    | 1.0333    | 1.0611    | 1.0909      | 1.1238    | 1.1631      | 1.3905    | 1.2143      | 1.2749  |
| 2.07E-01           | 2.06E-01  | 2.05E-01  | 2.03E-01  | 2.01E-01  | 1.98E-01  | 1.94E-01    | 1.89E-01  | 1.49E-01    | 1.81E-01  | 1.71E-01    |         |
| 3.50E+00*          | 7.42E+01  | 6.86E+02  | 3.56E+03  | 1.11E+04  | 2.08E+04  | 2.10E+04    | 8.13E+03  | ( 1.81E+01) | 2.72E+03  | 1.69E+03    |         |
| 3.58E+00*          | 7.57E+01* | 6.98E+02* | 3.61E+03* | 1.13E+04  | 2.09E+04  | 2.10E+04    | 8.03E+03  | 1.33E+01*   | 2.76E+03  | 1.67E+03    |         |
| 12                 | .4365     | .4716     | .5121     | .5592     | .6149     | .6815       | .7625     | .8633       | .9919     | 1.1616      | 1.3955  |
|                    | 22910.8   | 21205.4   | 19529.2   | 17881.9   | 16263.6   | 14674.3     | 13114.1   | 11583.0     | 10081.2   | 8608.8      | 7165.9  |
| 5.82E-07           | 1.72E-05  | 2.30E-04  | 1.82E-03  | 9.22E-03  | 3.06E-02  | 6.40E-02    | 7.33E-02  | 2.75E-02    | 3.08E-03  | 6.40E-02    |         |
|                    | .9453     | .9664     | .9893     | 1.0138    | 1.0400    | 1.0679      | 1.0980    | 1.1316      | 1.1752    | 1.1317      | 1.2245  |
| 2.08E-01           | 2.07E-01  | 2.06E-01  | 2.04E-01  | 2.02E-01  | 2.00E-01  | 1.97E-01    | 1.93E-01  | 1.87E-01    | 1.93E-01  | 1.80E-01    |         |
| 1.22E+00           | 2.84E+01  | 2.94E+02  | 1.76E+03  | 6.59E+03  | 1.57E+04  | 2.27E+04    | 1.72E+04  | 4.00E+03    | 2.96E+02  | 3.08E+03    |         |
| 1.25E+00*          | 2.90E+01* | 3.00E+02* | 1.79E+03* | 6.68E+03* | 1.58E+04  | 2.28E+04    | 1.71E+04  | 3.90E+03    | 3.25E+02* | 3.10E+03    |         |
| 13                 | .4145     | .4460     | .4821     | .5236     | .5721     | .6294       | .6979     | .7814       | .8853     | 1.0179      | 1.1932  |
|                    | 24125.7   | 22420.4   | 20744.1   | 19096.8   | 17478.5   | 15889.3     | 14329.1   | 12798.0     | 11296.2   | 9823.7      | 8380.8  |
| 1.75E-07           | 5.52E-06  | 8.00E-05  | 6.98E-04  | 4.01E-03  | 1.57E-02  | 4.12E-02    | 6.81E-02  | 5.81E-02    | 1.04E-02  | 1.35E-02    |         |
|                    | .9316     | .9512     | .9727     | .9958     | 1.0204    | 1.0466      | 1.0747    | 1.1052      | 1.1400    | 1.1942      | 1.1719  |
| 2.08E-01           | 2.07E-01  | 2.07E-01  | 2.05E-01  | 2.04E-01  | 2.02E-01  | 1.99E-01    | 1.96E-01  | 1.92E-01    | 1.84E-01  | 1.88E-01    |         |
| 4.31E-01           | 1.08E+01  | 1.24E+02  | 8.31E+02  | 3.61E+03  | 1.04E+04  | 1.95E+04    | 2.23E+04  | 1.25E+04    | 1.36E+03  | 1.13E+03    |         |
| 4.41E-01*          | 1.11E+01* | 1.26E+02* | 8.47E+02* | 3.67E+03* | 1.05E+04  | 1.97E+04    | 2.23E+04  | 1.24E+04    | 1.30E+03  | 1.18E+03    |         |
| 14                 | .3950     | .4235     | .4559     | .4929     | .5356     | .5854       | .6443     | .7148       | .8007     | .9078       | 1.0446  |
|                    | 25318.1   | 23612.8   | 21936.5   | 20289.2   | 18670.9   | 17081.7     | 15521.4   | 13990.4     | 12488.6   | 11016.1     | 9573.2  |
| 5.39E-08           | 1.80E-06  | 2.79E-05  | 2.65E-04  | 1.69E-03  | 7.53E-03  | 2.36E-02    | 5.00E-02  | 6.58E-02    | 4.03E-02  | 1.51E-03    |         |
|                    | .9186     | .9372     | .9573     | .9790     | 1.0023    | 1.0270      | 1.0533    | 1.0816      | 1.1126    | 1.1493      | 1.2519  |
| 2.08E-01           | 2.08E-01  | 2.07E-01  | 2.06E-01  | 2.05E-01  | 2.03E-01  | 2.01E-01    | 1.99E-01  | 1.95E-01    | 1.91E-01  | 1.75E-01    |         |
| 1.53E-01           | 4.14E+00  | 5.12E+01  | 3.81E+02  | 1.87E+03  | 6.29E+03  | 1.45E+04    | 2.19E+04  | 1.98E+04    | 7.95E+03  | ( 1.64E+02) |         |
| 1.57E-01*          | 4.23E+00* | 5.23E+01* | 3.89E+02* | 1.90E+03* | 6.38E+03* | 1.46E+04    | 2.21E+04  | 1.98E+04    | 7.83E+03  | 1.45E+02*   |         |
| 15                 | .3775     | .4035     | .4328     | .4660     | .5040     | .5479       | .5991     | .6596       | .7322     | .8206       | .9308   |
|                    | 26487.9   | 24782.6   | 23106.3   | 21459.1   | 19840.8   | 18251.5     | 16691.3   | 15160.2     | 13658.4   | 12185.9     | 10743.0 |
| 1.69E-08           | 5.94E-07  | 9.80E-06  | 9.97E-05  | 6.94E-04  | 3.45E-03  | 1.24E-02    | 3.18E-02  | 5.55E-02    | 5.78E-02  | 2.36E-02    |         |
|                    | .9060     | .9239     | .9429     | .9634     | .9854     | 1.0088      | 1.0337    | 1.0601      | 1.0886    | 1.1203      | 1.1606  |
| 2.08E-01           | 2.08E-01  | 2.08E-01  | 2.07E-01  | 2.06E-01  | 2.05E-01  | 2.03E-01    | 2.01E-01  | 1.98E-01    | 1.94E-01  | 1.89E-01    |         |
| 5.50E-02           | 1.58E+00  | 2.11E+01  | 1.71E+02  | 9.32E+02  | 3.56E+03  | 9.63E+03    | 1.81E+04  | 2.25E+04    | 1.60E+04  | 4.25E+03    |         |
| 5.63E-02*          | 1.62E+00* | 2.16E+01* | 1.75E+02* | 9.50E+02* | 3.62E+03* | 9.76E+03    | 1.83E+04  | 2.25E+04    | 1.59E+04  | 4.15E+03    |         |

Table 5. Radiative transition parameters for  $N_2$   $B' \ ^3\Sigma_u^- - B \ ^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 11   | 12   | 13   | 14  | 15  | 16   | 17  | 18   | 19   | 20  | 21  |  |            |
|---------------------|--|--|--|---|---|--|---|--|--|---|---|--|------------|
| 8                   | 15.0065<br>666.4   | -13.9500<br>-716.8   | -4.8312<br>-2069.9   | -2.9477<br>-3392.5  | -2.1348<br>-4684.3  | -1.6821<br>-5945.1   | -1.3938<br>-7174.4  | -1.1945<br>-8372.0   | -1.0485<br>-9537.4   | -.9372<br>-10670.1  | -.8496<br>-11769.8  |  |            |
| 3.25E-01            | 1.23E-01   | 8.69E-03   | 1.70E-06   | 1.73E-05  | 2.31E-09  | 4.54E-08   | 4.57E-10  | 8.22E-11   | 7.00E-12   | 7.52E-13  |   |  |            |
| 1.5014              | 1.5966   | 1.7842   | 6.6440   | 1.6297  | 9.9711  | 1.7366   | .6182   | 2.1699   | 1.5494   | 1.5562  |   |  |            |
| 1.25E-01            | 1.05E-01   | 6.97E-02   | 1.81E-21   | 9.87E-02  | 0.00E+00  | 7.81E-02   | 1.86E-01  | 2.18E-02   | 1.15E-01   | 1.14E-01  |   |  |            |
| 6.13E+00            | -1.02E+00  | (-7.57E-01)(-4.40E-43)(-3.51E-02)(0.00E+00)(-2.07E-04)(-1.89E-05)(-6.84E-08)(-2.29E-07)(-3.22E-08) | 6.15E+00   | -1.02E+00   | -6.70E-01*  | -1.16E-01*   | -2.81E-02*  | -2.97E-03*   | -1.13E-04*   | -5.37E-05*  | -4.43E-07*  | -1.31E-07*   | -1.92E-08* |
| 9                   | 5.0709<br>1972.0<br>5.37E-02<br>1.4865<br>1.29E-01<br>2.76E+01<br>2.71E+01 | 16.9831<br>588.8<br>3.34E-01<br>1.5135<br>1.23E-01<br>4.17E+00<br>4.18E+00                         | -13.0852<br>-764.2<br>1.46E-01<br>1.6096<br>6.50E-02<br>(-8.05E-01)(-9.33E-20)(-4.44E-02)(-3.43E-09)(-2.24E-04)<br>-6.87E-01 | -4.7920<br>-2086.8<br>2.95E-06<br>-2.8422<br>6.36E-10<br>8.59E-02<br>-2.32E-01*   | -2.9598<br>-3378.6<br>2.97E-05<br>1.6948<br>-1.1831<br>4.79E-04<br>-3.35E-02* | -2.1554<br>-4639.4<br>3.66E-08<br>1.8455<br>1.0805<br>5.95E-02<br>-7.33E-03*   | -1.7039<br>-5868.8<br>8.85E-08<br>2.71E-09<br>8.71E-11<br>1.99E-01<br>-7.14E-05*          | -1.4152<br>-7066.3<br>2.71E-09<br>2.7312<br>1.8300<br>1.90E-03<br>-1.31E-04*                       | -1.2148<br>-8231.7<br>2.02E-11<br>2.7312<br>1.8300<br>6.20E-02<br>-5.05E-06*   | -1.0679<br>-9364.5<br>-10464.1<br>2.7312<br>1.8300<br>1.90E-03<br>-2.56E-08*    | -0.9556<br>-10464.1<br>-1.0679<br>-1.2148<br>-1.0679<br>-1.2148<br>-0.9556      |  |            |
| 10                  | 3.0723<br>3254.9<br>1.13E-01<br>1.3466<br>1.57E-01<br>3.92E+02<br>3.93E+02 | 5.3427<br>1871.7<br>2.79E-02<br>1.5328<br>1.19E-01<br>2.75E+00<br>1.02E+01                         | 19.2800<br>518.7<br>3.37E-01<br>1.5263<br>1.20E-01<br>-1.77E+00<br>2.76E+00  | -12.4391<br>-803.9<br>1.68E-01<br>1.6231<br>1.00E-01<br>(-7.76E-01)(-3.38E-02)(-4.85E-02)(-4.40E-03)(-1.62E-04)(-3.05E-04)(-7.09E-36) | -4.7715<br>-2095.8<br>1.16E-02<br>1.8439<br>5.98E-02<br>1.08E-01<br>-6.25E-01 | -2.9793<br>-3356.5<br>3.76E-05<br>.2172<br>1.7636<br>7.33E-02<br>-4.15E-01*  | -2.1806<br>-4585.9<br>4.62E-05<br>1.7636<br>.5325<br>1.72E-01<br>-3.28E-02*               | -1.7291<br>-5783.5<br>3.78E-07<br>1.45E-07<br>1.9803<br>4.06E-02<br>-1.56E-02*                     | -1.4391<br>-6948.8<br>1.08E-08<br>2.01E-11<br>1.3185<br>1.63E-01<br>-1.39E-06* | -1.2374<br>-8081.6<br>-9181.2<br>2.01E-11<br>5.8073<br>4.75E-16<br>-2.60E-05*   | -1.0892<br>-9181.2<br>-1.2374<br>-1.4391<br>-1.2374<br>-1.4391<br>-1.0892       |  |            |
| 11                  | 2.2148<br>4515.1<br>1.10E-03<br>1.0952<br>1.97E-01<br>(1.60E+01)           | 3.1929<br>3131.9<br>1.17E-01<br>1.3562<br>1.56E-01<br>3.51E+02                                     | 5.6215<br>1778.9<br>3.36E-01<br>1.6178<br>1.01E-01<br>2.76E+00   | 21.9162<br>456.3<br>1.89E-01<br>1.5399<br>1.17E-01<br>1.78E+00  | -11.9680<br>-835.6<br>1.23E-02<br>1.6373<br>9.72E-02<br>-2.12E+00             | -4.7702<br>-2096.3<br>1.23E-02<br>1.8822<br>5.39E-02<br>(-6.70E-01)(-4.69E-01)(-4.40E-02)(-2.54E-02)(-5.47E-05)(-5.58E-04) | -3.0069<br>-3235.7<br>1.46E-04<br>.8577<br>2.08E-01<br>-2.38E+00                          | -2.2108<br>-4523.3<br>6.47E-05<br>1.8412<br>6.02E-02<br>(-5.02E-01)(-1.02E+00)(-3.06E-02)          | -1.7579<br>-5688.6<br>1.64E-06<br>1.0191<br>2.04E-01<br>-1.02E+00*             | -1.4660<br>-6821.4<br>1.88E-07<br>2.1767<br>2.12E-02<br>-2.91E-02*              | -1.2625<br>-7921.0<br>3.31E-08<br>1.4822<br>1.29E-01<br>-1.90E-04*              | -1.2625<br>-7921.0<br>-1.4660<br>-1.2625<br>-1.4660<br>-1.2625               |            |
| 12                  | 1.7383<br>5752.7<br>4.66E-02<br>1.2876<br>1.69E-01<br>1.02E+03             | 2.2886<br>4369.5<br>9.14E-03<br>1.2417<br>1.77E-01<br>9.65E+01                                     | 3.3152<br>3016.4<br>3.38E-03<br>1.3653<br>1.54E-01<br>2.93E+02   | 5.9037<br>1693.8<br>3.34E-01<br>1.8278<br>6.24E-02<br>(2.59E-01)  | 24.8754<br>402.0<br>2.09E-01<br>1.5544<br>1.14E-01<br>2.59E-01                | -11.6445<br>-858.8<br>2.09E-01<br>1.6522<br>9.42E-02<br>-2.38E+00  | -4.7890<br>-2088.1<br>1.22E-02<br>1.9296<br>4.72E-02<br>(-5.02E-01)(-1.02E+00)(-3.06E-02) | -3.0435<br>-3285.7<br>3.86E-04<br>1.1450<br>1.91E-01<br>-1.01E+00*                                 | -2.2467<br>-4451.1<br>8.01E-05<br>1.9367<br>4.62E-02<br>-8.41E-03*             | -1.7909<br>-5583.8<br>4.97E-06<br>1.2655<br>1.73E-01<br>-4.76E-02*              | -1.4962<br>-6683.5<br>1.70E-07<br>2.5510<br>4.58E-03<br>-1.54E-03*              | -1.4962<br>-6683.5<br>-1.7909<br>-1.4962<br>-1.4962<br>-1.4962               |            |
| 13                  | 1.4352<br>6967.7<br>6.84E-02<br>1.2340<br>1.78E-01<br>2.97E+03             | 1.7907<br>5584.4<br>2.69E-02<br>1.3041<br>1.66E-01<br>5.19E+02                                     | 2.3633<br>4231.4<br>2.14E-02<br>1.2747<br>1.52E-01<br>1.92E+02   | 3.4378<br>2908.8<br>1.01E-01<br>1.3740<br>3.28E-04<br>2.33E+02  | 6.1844<br>1617.0<br>2.49E-04<br>3.0467<br>1.11E-01<br>(4.60E-07)              | 28.0746<br>356.2<br>3.32E-01<br>1.5698<br>1.6680<br>7.50E-01   | -11.4526<br>-873.2<br>2.26E-01<br>1.9916<br>1.9916<br>-2.53E+00                           | -4.8292<br>-2070.7<br>1.12E-02<br>1.3151<br>1.3151<br>(-3.11E-01)(-1.52E+00)(-1.36E-02)(-8.01E-02) | -3.0901<br>-3236.1<br>8.29E-04<br>2.0685<br>2.0685<br>-1.04E+00*               | -2.2889<br>-4368.8<br>8.50E-05<br>1.4272<br>1.4272<br>-2.91E-02*                | -1.8287<br>-5468.5<br>1.22E-05<br>1.4272<br>1.4272<br>-1.90E-04*                | -1.8287<br>-5468.5<br>-2.2889<br>-1.8287<br>-1.8287<br>-1.8287               |            |
| 14                  | 1.2255<br>8160.1<br>2.66E-02<br>1.1881<br>1.85E-01<br>2.01E+03<br>2.06E+03 | 1.4756<br>6776.8<br>6.47E-02<br>1.2433<br>1.76E-01<br>2.54E+03<br>2.53E+03                         | 1.8437<br>5423.8<br>3.45E-02<br>1.5297<br>1.68E-01<br>2.03E+02<br>1.92E+02   | 2.4383<br>4101.2<br>7.873E-02<br>1.2922<br>1.50E-01<br>2.71E+02<br>2.70E+02   | 3.5595<br>2809.4<br>2.32E-04<br>1.3046<br>4.82E-02<br>1.77E+02<br>1.75E+02    | 6.4575<br>1548.6<br>1.86E-03<br>1.3046<br>1.08E-01<br>1.13E-02<br>1.06E+00*  | 31.3255<br>319.2<br>1.7195<br>1.5860<br>1.08E-01<br>5.15E-01<br>-2.55E+00                 | -11.3852<br>-878.3<br>1.90E-01<br>1.6848<br>8.79E-02<br>2.97E-02<br>-1.04E-02*                     | -4.8931<br>-2043.7<br>9.26E-03<br>2.0790<br>2.97E-02<br>1.40E-01<br>-1.75E+00* | -3.1482<br>-3176.4<br>1.55E-03<br>1.4332<br>1.40E-01<br>1.41E-02<br>-2.61E-02*  | -2.3386<br>-4276.1<br>7.13E-05<br>2.2864<br>1.41E-02<br>-2.16E-06<br>-2.61E-02* | -2.3386<br>-4276.1<br>-3.1482<br>-2.3386<br>-2.3386<br>-2.3386<br>-2.61E-02* |            |
| 15                  | 1.0718<br>9329.9<br>3.98E-04<br>1.0182<br>2.04E-01<br>(5.46E+01)           | 1.2584<br>7946.7<br>3.85E-02<br>1.1994<br>1.84E-01<br>2.64E+03                                     | 1.5166<br>6593.6<br>5.54E-02<br>1.2530<br>1.49E-01<br>1.97E+03   | 1.8972<br>5271.0<br>3.37E-03<br>1.3876<br>1.65E-01<br>4.01E+01  | 2.5131<br>3979.2<br>4.59E-02<br>1.3046<br>1.3900<br>3.25E+02                  | 3.6786<br>2718.4<br>7.26E-02<br>1.3046<br>1.7195<br>1.28E+02   | 6.7157<br>1489.1<br>1.86E-03<br>1.3900<br>1.04E-01<br>2.05E+00*                           | 34.3066<br>291.5<br>3.36E-01<br>1.6030<br>1.04E-01<br>3.73E-01                                     | -11.4432<br>-873.9<br>2.51E-01<br>1.7027<br>8.44E-02<br>-2.42E+00              | -4.9835<br>-2006.6<br>6.54E-03<br>2.2181<br>1.83E-02<br>-3.58E-02<br>-2.02E+00* | -3.2193<br>-3106.3<br>2.59E-03<br>1.5253<br>1.20E-01<br>-2.28E+00<br>-2.02E+00* | -3.2193<br>-3106.3<br>-4.9835<br>-3.2193<br>-3.2193<br>-3.2193<br>-2.02E+00* |            |

Table 5. Radiative transition parameters for  $N_2 B' ^3\Sigma_u^- - B ^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 0           | 1         | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9         | 10       |
|---------------------|-------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|
| 16                  | .3619       | .3857     | .4123     | .4424     | .4765     | .5155     | .5606     | .6132     | .6754     | .7500     | .8410    |
|                     | 27635.2     | 25929.9   | 24253.6   | 22606.3   | 20988.0   | 19398.7   | 17838.5   | 16307.4   | 14805.6   | 13333.2   | 11890.3  |
|                     | 5.35E-09    | 1.99E-07  | 3.46E-06  | 3.76E-05  | 2.82E-04  | 1.54E-03  | 6.19E-03  | 1.84E-02  | 3.94E-02  | 5.67E-02  | 4.61E-02 |
|                     | .8930       | .9110     | .9294     | .9488     | .9696     | .9918     | 1.0154    | 1.0403    | 1.0669    | 1.0957    | 1.1285   |
|                     | 2.08E-01    | 2.08E-01  | 2.08E-01  | 2.07E-01  | 2.07E-01  | 2.06E-01  | 2.04E-01  | 2.02E-01  | 2.00E-01  | 1.97E-01  | 1.93E-01 |
|                     | 1.98E-02    | 6.08E-01  | 8.65E+00  | 7.57E+01  | 4.51E+02  | 1.92E+03  | 5.94E+03  | 1.33E+04  | 2.08E+04  | 2.12E+04  | 1.18E+04 |
|                     | 2.03E-02*   | 6.22E-01* | 8.85E+00* | 7.73E+01* | 4.60E+02* | 1.96E+03* | 6.03E+03* | 1.34E+04  | 2.09E+04  | 2.12E+04  | 1.16E+04 |
| 17                  | .3477       | .3696     | .3940     | .4214     | .4522     | .4872     | .5273     | .5737     | .6277     | .6917     | .7683    |
|                     | 28759.8     | 27054.5   | 25378.2   | 23730.9   | 22112.6   | 20523.4   | 18963.1   | 17432.1   | 15930.2   | 14457.8   | 13014.9  |
|                     | 1.70E-09    | 6.70E-08  | 1.23E-06  | 1.42E-05  | 1.14E-04  | 6.70E-04  | 2.97E-03  | 9.97E-03  | 2.50E-02  | 4.50E-02  | 5.35E-02 |
|                     | .8786       | .8979     | .9162     | .9350     | .9548     | .9759     | .9983     | 1.0220    | 1.0470    | 1.0738    | 1.1030   |
|                     | 2.08E-01    | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.07E-01  | 2.06E-01  | 2.05E-01  | 2.04E-01  | 2.02E-01  | 1.99E-01  | 1.96E-01 |
|                     | 7.08E-03    | 2.33E-01  | 3.54E+00  | 3.31E+01  | 2.14E+02  | 1.00E+03  | 3.46E+03  | 8.89E+03  | 1.67E+04  | 2.19E+04  | 1.84E+04 |
|                     | 7.28E-03*   | 2.39E-01* | 3.62E+00* | 3.39E+01* | 2.18E+02* | 1.02E+03* | 3.52E+03* | 9.01E+03* | 1.68E+04  | 2.20E+04  | 1.84E+04 |
| 18                  | .3349       | .3552     | .3776     | .4027     | .4308     | .4624     | .4984     | .5395     | .5871     | .6427     | .7084    |
|                     | 29861.8     | 28156.5   | 26480.2   | 24832.9   | 23214.6   | 21625.3   | 20065.1   | 18534.0   | 17032.2   | 15559.8   | 14116.9  |
|                     | 5.34E-10    | 2.26E-08  | 4.40E-07  | 5.36E-06  | 4.56E-05  | 2.88E-04  | 1.39E-03  | 5.15E-03  | 1.46E-02  | 3.13E-02  | 4.78E-02 |
|                     | .8613       | .8837     | .9028     | .9215     | .9408     | .9610     | .9823     | 1.0048    | 1.0286    | 1.0537    | 1.0807   |
|                     | 2.08E-01    | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.07E-01  | 2.06E-01  | 2.05E-01  | 2.03E-01  | 2.01E-01  | 1.99E-01 |
|                     | 2.48E-03    | 8.83E-02  | 1.44E+00  | 1.44E+01  | 9.97E+01  | 5.06E+02  | 1.93E+03  | 5.58E+03  | 1.21E+04  | 1.94E+04  | 2.16E+04 |
|                     | 2.57E-03*   | 9.07E-02* | 1.47E+00* | 1.47E+01* | 1.02E+02* | 5.17E+02* | 1.97E+03* | 5.66E+03* | 1.23E+04  | 1.95E+04  | 2.16E+04 |
| 19                  | .3232       | .3420     | .3629     | .3859     | .4116     | .4404     | .4729     | .5099     | .5521     | .6010     | .6581    |
|                     | 30941.0     | 29235.7   | 27559.4   | 25912.2   | 24293.9   | 22704.6   | 21144.4   | 19613.3   | 18111.5   | 16639.0   | 15196.1  |
|                     | 1.62E-10    | 7.50E-09  | 1.57E-07  | 2.02E-06  | 1.83E-05  | 1.23E-04  | 6.36E-04  | 2.57E-03  | 8.12E-03  | 1.99E-02  | 3.65E-02 |
|                     | .8384       | .8667     | .8884     | .9079     | .9270     | .9467     | .9672     | .9887     | 1.0113    | 1.0352    | 1.0605   |
|                     | 2.07E-01    | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.07E-01  | 2.07E-01  | 2.06E-01  | 2.05E-01  | 2.03E-01  | 2.01E-01 |
|                     | 8.34E-04    | 3.28E-02  | 5.75E-01  | 6.17E+00  | 4.59E+01  | 2.51E+02  | 1.04E+03  | 3.33E+03  | 8.18E+03  | 1.53E+04  | 2.09E+04 |
|                     | 8.70E-04*   | 3.38E-02* | 5.91E-01* | 6.33E+00* | 4.69E+01* | 2.56E+02* | 1.06E+03* | 3.39E+03* | 8.30E+03* | 1.54E+04  | 2.11E+04 |
| 20                  | .3125       | .3301     | .3495     | .3708     | .3945     | .4209     | .4504     | .4838     | .5217     | .5651     | .6153    |
|                     | 31997.5     | 30292.2   | 28615.9   | 26968.6   | 25350.3   | 23761.0   | 22200.8   | 20669.7   | 19167.9   | 17695.5   | 16252.6  |
|                     | 4.58E-11    | 2.40E-09  | 5.48E-08  | 7.58E-07  | 7.27E-06  | 5.20E-05  | 2.87E-04  | 1.25E-03  | 4.33E-03  | 1.18E-02  | 2.51E-02 |
|                     | .8041       | .8443     | .8716     | .8935     | .9133     | .9328     | .9527     | .9735     | .9952     | 1.0179    | 1.0419   |
|                     | 2.05E-01    | 2.07E-01  | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.07E-01  | 2.07E-01  | 2.05E-01  | 2.04E-01  | 2.02E-01 |
|                     | 2.56E-04    | 1.10E-02  | 2.25E-01  | 2.61E+00  | 2.08E+01  | 1.22E+02  | 5.47E+02  | 1.91E+03  | 5.21E+03  | 1.11E+04  | 1.79E+04 |
|                     | 2.73E-04*   | 1.21E-02* | 2.32E-01* | 2.68E+00* | 2.13E+01* | 1.25E+02* | 5.59E+02* | 1.95E+03* | 5.30E+03* | 1.12E+04  | 1.81E+04 |
| 21                  | .3027       | .3192     | .3373     | .3571     | .3790     | .4033     | .4304     | .4608     | .4950     | .5339     | .5785    |
|                     | 33031.0     | 31325.7   | 29640.4   | 28002.1   | 26383.8   | 24704.6   | 23234.3   | 21703.3   | 20201.5   | 18729.0   | 17286.1  |
|                     | 1.10E-11    | 7.16E-10  | 1.86E-08  | 2.79E-07  | 2.87E-06  | 2.18E-05  | 1.28E-04  | 5.98E-04  | 2.23E-03  | 6.71E-03  | 1.60E-02 |
|                     | .7424       | .8108     | .8499     | .8769     | .8988     | .9189     | .9387     | .9589     | .9799     | 1.0017    | 1.0245   |
|                     | 2.01E-01    | 2.06E-01  | 2.07E-01  | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.08E-01  | 2.07E-01  | 2.06E-01  | 2.05E-01  | 2.04E-01 |
|                     | ( 6.52E-05) | 3.78E-03  | 8.42E-02  | 1.07E+00  | 9.25E+00  | 5.82E+01  | 2.81E+02  | 1.06E+03  | 3.18E+03  | 7.51E+03  | 1.39E+04 |
|                     | 7.34E-05*   | 4.02E-03* | 8.77E-02* | 1.11E+00* | 9.50E+00* | 5.97E+01* | 2.87E+02* | 1.08E+03* | 3.23E+03* | 7.63E+03* | 1.41E+04 |

Table 5 Radiative transition parameters for  $\text{N}_2 B' ^3\Sigma_u^- - B ^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 11   | 12  | 13  | 14  | 15  | 16  | 17   | 18   | 19  | 20   | 21   |        |
|---------------------|--|---|---|---|---|---|--|--|---|--|--|--------|
| 16                  | .9545<br>10477.1<br>1.06E-02<br>1.1765<br>1.87E-01<br>1.73E+03<br>1.66E+03 | 1.0996<br>9093.9<br>4.65E-02<br>1.1400<br>1.92E-01<br>5.75E+02<br>6.14E+02* | 1.2918<br>7740.9<br>4.32E-02<br>1.2090<br>1.73E-01<br>2.90E+03<br>2.92E+03  | 1.5581<br>6418.3<br>9.67E-05<br>1.2634<br>1.73E-01<br>1.39E+03<br>1.36E+03  | 1.9507<br>5126.4<br>5.43E-02<br>1.9243<br>1.64E-01<br>1.21E-01<br>5.46E-05* | 2.5869<br>3865.7<br>5.85E-02<br>1.3147<br>1.47E-01<br>3.40E+02<br>3.43E+02  | 3.7932<br>2636.3<br>3.56E-03<br>1.3966<br>2.08E-01<br>9.43E+01<br>9.21E+01 | 6.9506<br>1438.7<br>3.44E-01<br>.8595<br>1.01E-01<br>1.85E+00<br>2.83E+00* | 36.5813<br>273.4<br>2.57E-01<br>1.6208<br>8.08E-02<br>2.88E-01<br>2.95E-01  | -11.6363<br>-859.4<br>3.48E-03<br>1.7221<br>5.93E-03<br>-2.16E+00<br>-2.17E+00 | -5.1046<br>-1959.0<br>-2.4940<br>-1.7221<br>-1.87E-03<br>-2.71E-01*        |        |
| 17                  | .8619<br>11601.7<br>3.29E-02<br>1.1375<br>1.92E-01<br>7.71E+03<br>7.59E+03 | .9786<br>10218.5<br>2.76E-03<br>1.2100<br>1.82E-01<br>3.94E+02<br>3.61E+02* | 1.1280<br>8865.5<br>1.31E-02<br>1.1638<br>1.89E-01<br>1.32E+03<br>1.36E+03  | 1.3258<br>7542.9<br>4.97E-02<br>1.2179<br>1.81E-01<br>2.82E+03<br>2.83E+03  | 1.5997<br>6251.1<br>3.06E-02<br>1.2753<br>1.71E-01<br>8.85E+02<br>8.65E+02  | 2.0039<br>4990.3<br>1.08E-03<br>1.1015<br>1.97E-01<br>2.11E+01<br>2.58E+01* | 2.6589<br>3760.9<br>5.94E-02<br>1.3235<br>1.62E-01<br>3.36E+02<br>3.38E+02 | 3.9011<br>2563.4<br>4.59E-02<br>1.4014<br>6.71E+01<br>6.51E+01<br>6.51E+01 | 7.1531<br>1398.0<br>4.59E-03<br>.8609<br>2.19E+00<br>3.29E+00*              | 37.6997<br>265.3<br>3.58E-01<br>1.6392<br>2.54E-01<br>2.61E-01                 | -11.9846<br>-834.4<br>2.58E-01<br>1.7433<br>7.69E-02<br>-1.80E+00          |        |
| 18                  | .7872<br>12703.7<br>4.66E-02<br>1.1106<br>1.96E-01<br>1.48E+04<br>1.47E+04 | .8834<br>11320.5<br>1.89E-05<br>1.1479<br>1.91E-01<br>4.39E+03<br>4.29E+03  | 1.0033<br>9967.5<br>2.17E-02<br>1.8154<br>1.87E-01<br>3.14E-01<br>1.17E-03* | 1.1568<br>8644.9<br>4.85E-02<br>1.1773<br>1.2266<br>1.99E+03<br>2.03E+03    | 1.3600<br>7353.0<br>1.95E-02<br>1.2898<br>1.2078<br>5.06E+02<br>4.89E+02    | 1.6414<br>6092.3<br>4.82E-03<br>1.3316<br>1.4027<br>7.46E+01<br>8.09E+01*   | 2.0564<br>4862.9<br>6.15E-02<br>1.3316<br>1.4027<br>3.15E+02<br>4.55E+01   | 2.7283<br>3665.3<br>3.51E-02<br>1.4027<br>1.64E-01<br>4.74E+01<br>3.16E+02 | 4.0001<br>32500.0<br>4.51E-03<br>.7645<br>2.03E-01<br>9.31E-02<br>3.45E+00* | 7.3141<br>1367.2<br>3.79E-01<br>1.6581<br>9.31E-02<br>2.55E-01<br>2.64E-01     | 37.3734<br>267.6<br>3.79E-01<br>1.6581<br>9.31E-02<br>2.55E-01<br>37.3734  |        |
| 19                  | .7255<br>13783.0<br>4.75E-02<br>1.0878<br>1.98E-01<br>1.98E+04<br>1.98E+04 | .8065<br>12399.7<br>3.74E-02<br>1.1186<br>1.95E-01<br>1.10E+04<br>1.08E+04  | .9052<br>11046.7<br>1.04E-02<br>1.1617<br>1.89E-01<br>2.04E+03<br>1.96E+03  | 1.0284<br>9724.1<br>1.54E-03<br>1.0975<br>1.97E-01<br>1.85E-01<br>2.51E+02* | 1.1859<br>8432.3<br>2.92E-02<br>1.1877<br>1.2353<br>2.44E+03<br>2.48E+03    | 1.3944<br>7171.5<br>4.39E-02<br>1.2353<br>1.3096<br>2.07E+03<br>2.06E+03    | 1.6829<br>5942.1<br>1.08E-02<br>1.3096<br>1.2408<br>2.48E+02<br>2.36E+02   | 2.1077<br>4744.6<br>9.88E-03<br>1.77E-01<br>1.34E+02<br>1.41E+02*          | 2.7939<br>3579.2<br>6.12E-02<br>1.59E-01<br>2.86E+02<br>2.86E+02            | 4.0875<br>2446.5<br>2.61E-02<br>1.47E-01<br>3.56E+01<br>3.18E+01               | 7.4249<br>1346.8<br>3.23E-03<br>.4922<br>1.65E-01<br>8.69E-01<br>3.33E+00* | 7.4249 |
| 20                  | .6739<br>14839.4<br>4.00E-02<br>1.0674<br>2.00E-01<br>2.12E+04<br>2.13E+04 | .7432<br>13456.2<br>2.74E-02<br>1.0950<br>1.97E-01<br>1.69E+04<br>1.69E+04  | .8262<br>12103.2<br>3.70E-03<br>1.1272<br>1.94E-01<br>7.37E+03<br>7.25E+03  | .9276<br>10780.6<br>5.91E-03<br>1.1849<br>1.86E-01<br>6.48E+02<br>6.04E+02* | 1.0539<br>9488.7<br>3.43E-02<br>1.1398<br>1.92E-01<br>7.54E+02<br>7.98E+02* | 1.2154<br>8227.9<br>3.71E-02<br>1.1967<br>1.2443<br>2.07E+03<br>2.65E+03    | 1.4289<br>6998.6<br>4.82E-03<br>1.2443<br>1.3415<br>1.76E+01<br>1.58E+03   | 1.7238<br>5801.0<br>1.51E-02<br>1.2580<br>1.2482<br>1.74E-01<br>1.92E+02   | 2.1572<br>4635.7<br>5.92E-02<br>1.2580<br>1.3482<br>1.57E-01<br>2.54E+02    | 2.8548<br>3502.9<br>1.86E-02<br>1.3482<br>1.3772<br>1.51E-01<br>2.40E+01       | 4.1610<br>2403.3<br>1.86E-02<br>1.3772<br>1.51E-01<br>2.40E+01<br>4.1610   |        |
| 21                  | .6300<br>15873.0<br>2.98E-02<br>1.0486<br>2.02E-01<br>1.97E+04<br>1.98E+04 | .6901<br>14489.7<br>3.82E-02<br>1.0743<br>1.96E-01<br>1.35E+04<br>1.34E+04  | .7612<br>13136.7<br>1.78E-02<br>1.1025<br>1.92E-01<br>4.34E+04<br>4.30E+03  | .8464<br>11814.1<br>4.38E-04<br>1.1370<br>1.2692<br>4.93E+01*               | .9504<br>10522.3<br>1.16E-02<br>1.1573<br>1.2051<br>1.39E+03                | 1.0797<br>9261.5<br>3.66E-02<br>1.1573<br>1.2539<br>2.58E+03                | 1.2450<br>8032.1<br>2.95E-02<br>1.2051<br>1.4128<br>1.14E+03               | 1.4632<br>6834.6<br>1.40E-03<br>1.2539<br>1.4128<br>1.86E+01*              | 1.7639<br>5669.2<br>1.97E-02<br>1.2681<br>1.2681<br>2.27E+02                | 2.2044<br>4536.5<br>5.65E-02<br>1.2681<br>1.3594<br>2.22E+02                   | 2.9097<br>3436.8<br>5.65E-02<br>1.3594<br>1.55E-01<br>2.23E+02             | 2.9097 |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 6. Radiative transition parameters for  $N_2$   $a^1\Pi_g - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units), and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $v' \backslash v''$ | 0        | 1         | 2         | 3         | 4         | 5         | 6        | 7         | 8         | 9         | 10        |
|---------------------|----------|-----------|-----------|-----------|-----------|-----------|----------|-----------|-----------|-----------|-----------|
| 0                   | .1450    | .1501     | .1555     | .1612     | .1672     | .1736     | .1805    | .1878     | .1956     | .2040     | .2130     |
|                     | 68951.3  | 66620.9   | 64319.3   | 62046.5   | 59802.4   | 57587.2   | 55400.7  | 53243.1   | 51114.4   | 49014.6   | 46943.9   |
|                     | 4.28E-02 | 1.51E-01  | 2.48E-01  | 2.50E-01  | 1.73E-01  | 8.77E-02  | 3.35E-02 | 9.88E-03  | 2.28E-03  | 4.12E-04  | 5.88E-05  |
|                     | 1.1578   | 1.1807    | 1.2043    | 1.2287    | 1.2541    | 1.2806    | 1.3083   | 1.3373    | 1.3680    | 1.4005    | 1.4351    |
|                     | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 9.83E+02 | 3.14E+03  | 4.63E+03  | 4.19E+03  | 2.60E+03  | 1.17E+03  | 3.99E+02 | 1.04E+02* | 2.13E+01* | 3.40E+00* | 4.26E-01* |
| 1                   | .1416    | .1464     | .1515     | .1570     | .1627     | .1688     | .1752    | .1821     | .1895     | .1973     | .2057     |
|                     | 70617.6  | 68287.2   | 65985.6   | 63712.8   | 61468.8   | 59253.5   | 57067.0  | 54909.4   | 52780.7   | 50681.0   | 48610.2   |
|                     | 1.15E-01 | 1.93E-01  | 8.09E-02  | 4.22E-04  | 8.85E-02  | 1.87E-01  | 1.76E-01 | 1.02E-01  | 4.14E-02  | 1.23E-02  | 2.75E-03  |
|                     | 1.1414   | 1.1633    | 1.1849    | 1.2447    | 1.2374    | 1.2618    | 1.2880   | 1.3155    | 1.3445    | 1.3751    | 1.4076    |
|                     | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 2.85E+03 | 4.31E+03  | 1.63E+03  | 7.65E+00* | 1.44E+03  | 2.72E+03  | 2.20E+03 | 1.19E+03  | 4.27E+02  | 1.12E+02  | 2.21E+01* |
| 2                   | .1384    | .1430     | .1479     | .1530     | .1585     | .1642     | .1703    | .1768     | .1838     | .1911     | .1990     |
|                     | 72256.1  | 69925.8   | 67624.2   | 65351.3   | 63107.3   | 60892.0   | 58705.6  | 56547.9   | 54419.2   | 52319.5   | 50248.8   |
|                     | 1.70E-01 | 9.74E-02  | 3.15E-03  | 1.08E-01  | 8.58E-02  | 6.97E-04  | 6.68E-02 | 1.67E-01  | 1.61E-01  | 9.23E-02  | 3.56E-02  |
|                     | 1.1258   | 1.1463    | 1.1809    | 1.1939    | 1.2157    | 1.2091    | 1.2709   | 1.2958    | 1.3230    | 1.3518    | 1.3824    |
|                     | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 4.50E+03 | 2.33E+03  | 6.83E+01* | 2.10E+03  | 1.51E+03  | 1.10E+01* | 9.47E+02 | 2.11E+03  | 1.82E+03  | 9.26E+02  | 3.16E+02  |
| 3                   | .1354    | .1398     | .1444     | .1493     | .1545     | .1600     | .1658    | .1719     | .1785     | .1854     | .1928     |
|                     | 73866.9  | 71536.5   | 69234.9   | 66962.1   | 64718.1   | 62502.8   | 60316.3  | 58158.7   | 56030.0   | 53930.2   | 51859.5   |
|                     | 1.83E-01 | 1.26E-02  | 7.50E-02  | 6.95E-02  | 3.72E-03  | 9.59E-02  | 6.48E-02 | 3.37E-04  | 8.24E-02  | 1.66E-01  | 1.42E-01  |
|                     | 1.1109   | 1.1278    | 1.1553    | 1.1750    | 1.2126    | 1.2247    | 1.2465   | 1.3311    | 1.3047    | 1.3308    | 1.3594    |
|                     | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 5.16E+03 | 3.22E+02  | 1.74E+03  | 1.46E+03  | 7.06E+01* | 1.64E+03  | 9.96E+02 | 4.65E+00* | 1.02E+03  | 1.83E+03  | 1.39E+03  |
| 4                   | .1325    | .1368     | .1412     | .1459     | .1508     | .1560     | .1616    | .1674     | .1736     | .1801     | .1871     |
|                     | 75449.9  | 73119.6   | 70818.0   | 68545.2   | 66301.1   | 64085.9   | 61899.4  | 59741.8   | 57613.1   | 55513.3   | 53442.6   |
|                     | 1.60E-01 | 6.01E-03  | 9.66E-02  | 6.19E-04  | 7.76E-02  | 3.69E-02  | 1.78E-02 | 9.74E-02  | 3.41E-02  | 1.12E-02  | 1.14E-01  |
|                     | 1.0966   | 1.1238    | 1.1387    | 1.1333    | 1.1843    | 1.2032    | 1.2370   | 1.2558    | 1.2768    | 1.3197    | 1.3393    |
|                     | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 4.82E+03 | 1.65E+02* | 2.40E+03  | 1.40E+01* | 1.58E+03  | 6.79E+02  | 2.96E+02 | 1.45E+03  | 4.57E+02  | 1.35E+02  | 1.22E+03  |
| 5                   | .1299    | .1339     | .1382     | .1427     | .1474     | .1523     | .1576    | .1631     | .1690     | .1752     | .1818     |
|                     | 77005.4  | 74675.1   | 72373.5   | 70100.6   | 67856.6   | 65641.3   | 63454.9  | 61297.2   | 59168.5   | 57068.8   | 54998.1   |
|                     | 1.22E-01 | 4.61E-02  | 4.72E-02  | 3.36E-02  | 5.67E-02  | 8.64E-03  | 7.89E-02 | 7.10E-03  | 4.92E-02  | 8.44E-02  | 6.09E-03  |
|                     | 1.0830   | 1.1053    | 1.1226    | 1.1485    | 1.1659    | 1.1985    | 1.2132   | 1.2262    | 1.2658    | 1.2873    | 1.3002    |
|                     | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 3.90E+03 | 1.34E+03  | 1.25E+03  | 8.10E+02  | 1.24E+03  | 1.71E+02* | 1.41E+03 | 1.15E+02* | 7.14E+02  | 1.10E+03  | 7.10E+01* |
| 6                   | .1273    | .1312     | .1353     | .1396     | .1441     | .1489     | .1539    | .1592     | .1648     | .1707     | .1769     |
|                     | 78533.3  | 76203.0   | 73901.4   | 71628.6   | 69384.5   | 67169.2   | 64982.8  | 62825.2   | 60696.5   | 58596.7   | 56526.0   |
|                     | 8.34E-02 | 8.45E-02  | 4.80E-03  | 7.26E-02  | 2.81E-03  | 6.36E-02  | 1.43E-02 | 4.17E-02  | 5.36E-02  | 2.90E-03  | 8.13E-02  |
|                     | 1.0698   | 1.0909    | 1.1031    | 1.1317    | 1.1396    | 1.1754    | 1.1905   | 1.2234    | 1.2420    | 1.2904    | 1.2967    |
|                     | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 2.83E+03 | 2.62E+03  | 1.36E+02* | 1.87E+03  | 6.58E+01* | 1.35E+03  | 2.74E+02 | 7.25E+02  | 8.40E+02  | 4.09E+01* | 1.03E+03  |
| 7                   | .1249    | .1287     | .1326     | .1367     | .1411     | .1456     | .1504    | .1555     | .1608     | .1664     | .1723     |
|                     | 80033.8  | 77703.5   | 75401.9   | 73129.1   | 70885.0   | 68669.7   | 66483.3  | 64325.7   | 62197.0   | 60097.2   | 58026.5   |
|                     | 5.28E-02 | 9.92E-02  | 5.47E-03  | 5.67E-02  | 1.71E-02  | 4.67E-02  | 1.33E-02 | 5.68E-02  | 1.47E-03  | 6.84E-02  | 1.31E-02  |
|                     | 1.0572   | 1.0776    | 1.1038    | 1.1165    | 1.1427    | 1.1578    | 1.1879   | 1.2027    | 1.2533    | 1.2519    | 1.2671    |
|                     | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 1.90E+03 | 3.26E+03  | 1.64E+02* | 1.55E+03  | 4.26E+02  | 1.06E+03  | 2.73E+02 | 1.06E+03  | 2.48E+01* | 1.04E+03  | 1.80E+02  |

Table 6. Radiative transition parameters for  $N_2 \alpha^1\Pi_g - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units), and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 11        | 12        | 13        | 14        | 15        | 16        | 17        | 18        | 19        | 20        | 21      |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| 0                   | .2227     | .2332     | .2445     | .2567     | .2701     | .2846     | .3006     | .3181     | .3375     | .3590     | .3830   |
|                     | 44902.3   | 42889.9   | 40906.7   | 38953.0   | 37028.9   | 35134.3   | 33269.6   | 31434.9   | 29630.3   | 27856.0   | 26112.1 |
| 6.59E-06            | 5.75E-07  | 3.86E-08  | 1.95E-09  | 7.20E-11  | 1.85E-12  | 2.18E-14  | 3.24E-16  | 4.19E-16  | 2.46E-16  | 3.30E-17  |         |
| 1.4724              | 1.5129    | 1.5575    | 1.6076    | 1.6641    | 1.7306    | 1.9218    | 1.8591    | 1.2575    | 1.2008    | 1.2536    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 4.18E-02*           | 3.18E-03* | 1.85E-04* | 8.06E-06* | 2.56E-07* | 5.63E-09* | 5.62E-11* | 7.06E-13* | 7.64E-13* | 3.72E-13* | 4.12E-14* |         |
| 1                   | .2147     | .2244     | .2349     | .2462     | .2584     | .2717     | .2862     | .3021     | .3195     | .3387     | .3600   |
|                     | 46568.6   | 44556.2   | 42573.1   | 40619.4   | 38695.2   | 36800.7   | 34936.0   | 33101.2   | 31296.6   | 29522.3   | 27778.5 |
| 4.69E-04            | 6.14E-05  | 6.15E-06  | 4.66E-07  | 2.62E-08  | 1.06E-09  | 2.92E-11  | 5.03E-13  | 3.06E-15  | 7.35E-17  | 1.74E-17  |         |
| 1.4423              | 1.4797    | 1.5203    | 1.5651    | 1.6155    | 1.6739    | 1.7440    | 1.8331    | 2.1335    | 1.6000    | 1.2260    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 3.32E+00*           | 3.81E-01* | 3.32E-02* | 2.19E-03* | 1.06E-04* | 3.69E-06* | 8.73E-08* | 1.28E-09* | 6.57E-12* | 1.32E-13* | 2.61E-14* |         |
| 2                   | .2074     | .2165     | .2262     | .2366     | .2479     | .2602     | .2734     | .2879     | .3036     | .3209     | .3399   |
|                     | 48207.1   | 46194.7   | 44211.6   | 42257.9   | 40333.7   | 38439.2   | 36574.5   | 34739.8   | 32935.1   | 31160.8   | 29417.0 |
| 9.83E-03            | 2.00E-03  | 3.06E-04  | 3.50E-05  | 2.99E-06  | 1.86E-07  | 8.24E-09  | 2.45E-10  | 4.61E-12  | 4.03E-14  | 4.97E-16  |         |
| 1.4149              | 1.4496    | 1.4871    | 1.5278    | 1.5729    | 1.6236    | 1.6828    | 1.7551    | 1.8384    | 2.0007    | .8867     |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 7.72E+01*           | 1.38E+01* | 1.85E+00* | 1.85E-01* | 1.37E-02* | 7.42E-04* | 2.82E-05* | 7.18E-07* | 1.15E-08* | 8.54E-11* | 8.86E-13* |         |
| 3                   | .2007     | .2092     | .2182     | .2280     | .2384     | .2497     | .2619     | .2751     | .2895     | .3051     | .3223   |
|                     | 49817.9   | 47805.5   | 45822.4   | 43868.7   | 41944.5   | 40050.0   | 38185.3   | 36350.5   | 34545.9   | 32771.6   | 31027.7 |
| 7.25E-02            | 2.49E-02  | 6.07E-03  | 1.08E-03  | 1.41E-04  | 1.35E-05  | 9.32E-07  | 4.51E-08  | 1.43E-09  | 2.74E-11  | 2.80E-13  |         |
| 1.3898              | 1.4223    | 1.4571    | 1.4946    | 1.5355    | 1.5808    | 1.6320    | 1.6916    | 1.7658    | 1.8618    | 1.9756    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 6.28E+02            | 1.91E+02  | 4.09E+01* | 6.38E+00* | 7.29E-01* | 6.07E-02* | 3.64E-03* | 1.52E-04* | 4.14E-06* | 6.76E-08* | 5.85E-10* |         |
| 4                   | .1945     | .2025     | .2109     | .2200     | .2297     | .2402     | .2515     | .2636     | .2768     | .2911     | .3066   |
|                     | 51401.0   | 49388.6   | 47405.4   | 45451.7   | 43527.5   | 41633.0   | 39768.3   | 37933.6   | 36129.0   | 34354.7   | 32610.8 |
| 1.64E-01            | 1.15E-01  | 4.97E-02  | 1.46E-02  | 3.01E-03  | 4.49E-04  | 4.82E-05  | 3.68E-06  | 1.93E-07  | 6.61E-09  | 1.29E-10  |         |
| 1.3672              | 1.3975    | 1.4299    | 1.4647    | 1.5023    | 1.5434    | 1.5889    | 1.6405    | 1.7008    | 1.7759    | 1.8809    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 1.56E+03            | 9.71E+02  | 3.71E+02  | 9.58E+01  | 1.74E+01* | 2.27E+00* | 2.12E-01* | 1.41E-02* | 6.39E-04* | 1.88E-05* | 3.14E-07* |         |
| 5                   | .1888     | .1963     | .2042     | .2127     | .2218     | .2315     | .2420     | .2532     | .2654     | .2785     | .2927   |
|                     | 52956.4   | 50944.0   | 48960.9   | 47007.2   | 45083.0   | 43188.5   | 41323.8   | 39489.1   | 37684.4   | 35910.1   | 34166.3 |
| 4.48E-02            | 1.46E-01  | 1.49E-01  | 8.26E-02  | 2.93E-02  | 7.08E-03  | 1.20E-03  | 1.44E-04  | 1.21E-05  | 6.93E-07  | 2.52E-08  |         |
| 1.3497              | 1.3755    | 1.4054    | 1.4377    | 1.4725    | 1.5101    | 1.5514    | 1.5972    | 1.6492    | 1.7105    | 1.7871    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 4.66E+02            | 1.35E+03  | 1.22E+03  | 6.01E+02  | 1.88E+02  | 3.99E+01* | 5.94E+00* | 6.22E-01* | 4.55E-02* | 2.25E-03* | 7.05E-05* |         |
| 6                   | .1835     | .1906     | .1981     | .2060     | .2145     | .2236     | .2334     | .2438     | .2550     | .2671     | .2802   |
|                     | 54484.4   | 52471.9   | 50488.8   | 48535.1   | 46610.9   | 44716.4   | 42851.7   | 41017.0   | 39212.4   | 37438.0   | 35694.2 |
| 4.77E-02            | 3.37E-03  | 9.64E-02  | 1.60E-01  | 1.18E-01  | 5.10E-02  | 1.45E-02  | 2.80E-03  | 3.77E-04  | 3.49E-05  | 2.15E-06  |         |
| 1.3186              | 1.3761    | 1.3846    | 1.4135    | 1.4456    | 1.4804    | 1.5181    | 1.5595    | 1.6056    | 1.6582    | 1.7204    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 5.40E+02            | 3.41E+01* | 8.69E+02  | 1.28E+03  | 8.35E+02  | 3.19E+02  | 7.97E+01  | 1.35E+01* | 1.59E+00* | 1.28E-01* | 6.86E-03* |         |
| 7                   | .1786     | .1853     | .1923     | .1999     | .2079     | .2164     | .2255     | .2352     | .2456     | .2568     | .2689   |
|                     | 55984.9   | 53972.4   | 51989.3   | 50035.6   | 48111.4   | 46216.9   | 44352.2   | 42517.5   | 40712.9   | 38938.5   | 37194.7 |
| 5.65E-02            | 8.24E-02  | 8.31E-03  | 4.05E-02  | 1.43E-01  | 1.46E-01  | 7.87E-02  | 2.63E-02  | 5.83E-03  | 8.78E-04  | 8.92E-05  |         |
| 1.3077              | 1.3288    | 1.3429    | 1.3958    | 1.4221    | 1.4538    | 1.4885    | 1.5263    | 1.5678    | 1.6142    | 1.6673    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 4.46E+02            | 9.08E+02  | 8.18E+01* | 3.55E+02  | 1.12E+03  | 1.01E+03  | 4.81E+02  | 1.42E+02  | 2.76E+01* | 3.63E+00* | 3.22E-01* |         |

Table 6. Radiative transition parameters for  $N_2 a^1\Pi_g - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units), and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v'\backslash v''$ | 0         | 1        | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9         | 10      |
|--------------------|-----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| 8                  | .1227     | .1263    | .1301     | .1340     | .1382     | .1426     | .1472     | .1520     | .1571     | .1624     | .1681   |
|                    | 81507.0   | 79176.6  | 76875.0   | 74602.2   | 72358.1   | 70142.9   | 67956.4   | 65798.8   | 63670.1   | 61570.3   | 59499.6 |
| 3.15E-02           | 9.21E-02  | 3.30E-02 | 1.86E-02  | 5.32E-02  | 4.12E-03  | 5.46E-02  | 4.27E-03  | 5.14E-02  | 1.59E-02  | 3.42E-02  |         |
| 1.0450             | 1.0648    | 1.0865   | 1.1009    | 1.1256    | 1.1347    | 1.1674    | 1.1756    | 1.2126    | 1.2272    | 1.2628    |         |
| 5.88E-03           | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 1.20E+03           | 3.20E+03  | 1.05E+03 | 5.40E+02  | 1.41E+03  | 9.96E+01* | 1.20E+03  | 8.52E+01* | 9.29E+02  | 2.59E+02  | 5.05E+02  |         |
| 9                  | .1206     | .1240    | .1277     | .1315     | .1355     | .1397     | .1441     | .1487     | .1536     | .1587     | .1641   |
|                    | 82952.9   | 80622.5  | 78320.9   | 76048.1   | 73804.1   | 71588.8   | 69402.3   | 67244.7   | 65116.0   | 63016.3   | 60945.5 |
| 1.79E-02           | 7.37E-02  | 6.04E-02 | 1.69E-04  | 5.48E-02  | 9.31E-03  | 3.93E-02  | 1.66E-02  | 3.76E-02  | 1.32E-02  | 4.94E-02  |         |
| 1.0333             | 1.0527    | 1.0730   | 1.0522    | 1.1109    | 1.1380    | 1.1505    | 1.1791    | 1.1930    | 1.2258    | 1.2397    |         |
| 5.88E-03           | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 7.17E+02           | 2.71E+03  | 2.03E+03 | 5.20E+00* | 1.54E+03  | 2.39E+02* | 9.20E+02  | 3.53E+02  | 7.28E+02  | 2.31E+02  | 7.84E+02  |         |
| 10                 | .1185     | .1219    | .1254     | .1291     | .1329     | .1370     | .1412     | .1456     | .1503     | .1552     | .1603   |
|                    | 84371.6   | 82041.3  | 79739.7   | 77466.9   | 75222.8   | 73007.6   | 70821.1   | 68663.5   | 66534.8   | 64435.0   | 62364.3 |
| 9.85E-03           | 5.32E-02  | 7.34E-02 | 9.44E-03  | 2.81E+02  | 3.92E-02  | 4.85E-03  | 4.77E-02  | 6.68E-04  | 4.98E-02  | 1.16E-03  |         |
| 1.0220             | 1.0409    | 1.0606   | 1.0840    | 1.0965    | 1.1202    | 1.1293    | 1.1603    | 1.1476    | 1.2033    | 1.1953    |         |
| 5.88E-03           | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 4.14E+02*          | 2.06E+03  | 2.61E+03 | 3.07E+02* | 8.37E+02  | 1.07E+03  | 1.21E+02* | 1.08E+03  | 1.38E+01* | 9.33E+02  | 1.96E+01* |         |
| 11                 | .1166     | .1199    | .1233     | .1268     | .1305     | .1344     | .1385     | .1427     | .1472     | .1519     | .1568   |
|                    | 85763.4   | 83433.1  | 81131.5   | 78858.6   | 76614.6   | 74399.3   | 72212.9   | 70055.3   | 67926.5   | 65826.8   | 63756.1 |
| 5.26E-03           | 3.56E-02  | 7.15E-02 | 3.15E-02  | 4.64E-03  | 4.91E-02  | 5.11E-03  | 3.39E-02  | 1.84E-02  | 2.38E-02  | 2.45E-02  |         |
| 1.0111             | 1.0297    | 1.0489   | 1.0695    | 1.0794    | 1.1059    | 1.1346    | 1.1441    | 1.1716    | 1.1841    | 1.2145    |         |
| 5.88E-03           | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 2.32E+02*          | 1.45E+03  | 2.68E+03 | 1.08E+03  | 1.46E+02* | 1.42E+03  | 1.35E+02* | 8.16E+02  | 4.04E+02  | 4.76E+02  | 4.45E+02  |         |
| 12                 | .1148     | .1179    | .1212     | .1247     | .1282     | .1320     | .1359     | .1400     | .1443     | .1488     | .1536   |
|                    | 87128.3   | 84797.9  | 82496.4   | 80223.5   | 77979.5   | 75764.2   | 73577.7   | 71420.1   | 69291.4   | 67191.7   | 65120.9 |
| 2.75E-03           | 2.26E-02  | 6.05E-02 | 5.06E-02  | 1.10E-03  | 3.29E-02  | 2.89E-02  | 5.42E-03  | 4.20E-02  | 2.81E-06  | 4.31E-02  |         |
| 1.0005             | 1.0188    | 1.0376   | 1.0572    | 1.0897    | 1.0924    | 1.1156    | 1.1245    | 1.1541    | 1.6827    | 1.1951    |         |
| 5.88E-03           | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 1.27E+02*          | 9.64E+02  | 2.38E+03 | 1.83E+03  | 3.67E+01* | 1.00E+03  | 8.06E+02  | 1.38E+02* | 9.78E+02  | 5.98E-02* | 8.33E+02  |         |
| 13                 | .1130     | .1161    | .1193     | .1226     | .1261     | .1297     | .1335     | .1374     | .1416     | .1459     | .1505   |
|                    | 88466.4   | 86136.1  | 83834.5   | 81561.6   | 79317.6   | 77102.3   | 74915.9   | 72758.2   | 70629.5   | 68529.8   | 66459.1 |
| 1.41E-03           | 1.37E-02  | 4.64E-02 | 5.93E-02  | 1.38E-02  | 1.09E-02  | 4.24E-02  | 2.59E-03  | 3.00E-02  | 1.88E-02  | 1.48E-02  |         |
| .9903              | 1.0084    | 1.0268   | 1.0458    | 1.0673    | 1.0781    | 1.1017    | 1.1332    | 1.1386    | 1.1653    | 1.1759    |         |
| 5.88E-03           | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 6.86E+01*          | 6.13E+02  | 1.92E+03 | 2.25E+03  | 4.82E+02  | 3.49E+02  | 1.25E+03  | 7.00E+01* | 7.39E+02  | 4.24E+02  | 3.05E+02  |         |
| 14                 | .1114     | .1144    | .1174     | .1207     | .1240     | .1275     | .1312     | .1350     | .1390     | .1432     | .1476   |
|                    | 89777.9   | 87447.6  | 85146.0   | 82873.1   | 80629.1   | 78413.8   | 76227.4   | 74069.7   | 71941.0   | 69841.3   | 67770.6 |
| 7.19E-04           | 8.05E-03  | 3.32E-02 | 5.79E-02  | 3.12E-02  | 2.50E-04  | 3.46E-02  | 2.10E-02  | 6.07E-03  | 3.71E-02  | 3.79E-04  |         |
| .9805              | .9983     | 1.0163   | 1.0349    | 1.0547    | 1.0398    | 1.0888    | 1.1119    | 1.1205    | 1.1488    | 1.2111    |         |
| 5.88E-03           | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 3.65E+01*          | 3.77E+02* | 1.43E+03 | 2.31E+03  | 1.14E+03  | 8.44E+00* | 1.07E+03  | 5.97E+02  | 1.58E+02* | 8.86E+02  | 8.26E+00* |         |
| 15                 | .1098     | .1127    | .1157     | .1188     | .1221     | .1255     | .1290     | .1327     | .1366     | .1406     | .1448   |
|                    | 91062.9   | 88732.6  | 86431.0   | 84158.2   | 81914.1   | 79698.8   | 77512.4   | 75354.8   | 73226.1   | 71126.3   | 69055.6 |
| 3.63E-04           | 4.61E-03  | 2.24E-02 | 5.00E-02  | 4.42E-02  | 4.29E-03  | 1.65E-02  | 3.57E-02  | 1.04E-03  | 2.72E-02  | 1.81E-02  |         |
| .9710              | .9885     | 1.0063   | 1.0245    | 1.0435    | 1.0677    | 1.0758    | 1.0983    | 1.1358    | 1.1340    | 1.1599    |         |
| 5.88E-03           | 5.88E-03  | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 1.92E+01*          | 2.26E+02* | 1.01E+03 | 2.09E+03  | 1.70E+03  | 1.52E+02* | 5.38E+02  | 1.07E+03  | 2.87E+01* | 6.85E+02  | 4.18E+02  |         |

Table 6. Radiative transition parameters for  $\text{N}_2$   $a^1\text{II}_g - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units), and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| $v' \backslash v''$ | 11        | 12        | 13        | 14        | 15        | 16        | 17        | 18        | 19        | 20        | 21      |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| 8                   | .1740     | .1804     | .1870     | .1941     | .2017     | .2097     | .2182     | .2273     | .2370     | .2475     | .2586   |
|                     | 57458.0   | 55445.6   | 53462.5   | 51508.8   | 49584.6   | 47690.1   | 45825.4   | 43990.6   | 42186.0   | 40411.7   | 38667.8 |
| 5.11E-02            | 2.34E-03  | 7.72E-02  | 4.34E-02  | 5.16E-03  | 1.03E-01  | 1.59E-01  | 1.09E-01  | 4.34E-02  | 1.10E-02  | 1.86E-03  |         |
| 1.2809              | 1.3373    | 1.3385    | 1.3604    | 1.4199    | 1.4315    | 1.4623    | 1.4968    | 1.5346    | 1.5763    | 1.6230    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 6.79E+02            | 2.79E+01* | 8.27E+02  | 4.15E+02  | 4.41E+01* | 7.82E+02  | 1.07E+03  | 6.51E+02  | 2.28E+02  | 5.10E+01  | 7.53E+00* |         |
| 9                   | .1698     | .1758     | .1821     | .1888     | .1960     | .2035     | .2115     | .2201     | .2292     | .2389     | .2493   |
|                     | 58903.9   | 56891.5   | 54908.4   | 52954.7   | 51030.5   | 49136.0   | 47271.3   | 45436.5   | 43631.9   | 41857.6   | 40113.8 |
| 2.26E-03            | 6.43E-02  | 8.99E-03  | 4.11E-02  | 7.55E-02  | 3.34E-03  | 5.45E-02  | 1.52E-01  | 1.37E-01  | 6.56E-02  | 1.92E-02  |         |
| 1.2902              | 1.2912    | 1.3033    | 1.3496    | 1.3712    | 1.3729    | 1.4424    | 1.4712    | 1.5053    | 1.5431    | 1.5850    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 3.24E+01*           | 8.29E+02  | 1.04E+02* | 4.28E+02  | 7.03E+02  | 2.77E+01* | 4.03E+02  | 9.97E+02  | 7.97E+02  | 3.37E+02  | 8.69E+01  |         |
| 10                  | .1658     | .1715     | .1775     | .1839     | .1907     | .1978     | .2054     | .2134     | .2220     | .2311     | .2408   |
|                     | 60322.7   | 58310.3   | 56327.1   | 54373.4   | 52449.3   | 50554.7   | 48690.0   | 46855.3   | 45050.7   | 43276.4   | 41532.5 |
| 5.07E-02            | 8.93E-03  | 4.01E-02  | 4.03E-02  | 7.48E-03  | 8.02E-02  | 2.85E-02  | 1.59E-02  | 1.24E-01  | 1.56E-01  | 9.15E-02  |         |
| 1.2500              | 1.2611    | 1.3020    | 1.3199    | 1.3691    | 1.3813    | 1.4019    | 1.4590    | 1.4806    | 1.5141    | 1.5518    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 7.79E+02            | 1.24E+02* | 5.02E+02  | 4.54E+02  | 7.56E+01* | 7.26E+02  | 2.30E+02  | 1.15E+02  | 7.97E+02  | 8.87E+02  | 4.59E+02  |         |
| 11                  | .1620     | .1675     | .1733     | .1793     | .1857     | .1925     | .1997     | .2073     | .2153     | .2239     | .2330   |
|                     | 61714.4   | 59702.0   | 57718.9   | 55765.2   | 53841.0   | 51946.5   | 50081.8   | 48247.1   | 46442.4   | 44668.1   | 42924.3 |
| 2.46E-02            | 2.15E-02  | 3.78E-02  | 8.48E-03  | 6.08E-02  | 1.67E-03  | 5.64E-02  | 6.07E-02  | 1.42E-04  | 8.45E-02  | 1.62E-01  |         |
| 1.2279              | 1.2621    | 1.2768    | 1.3193    | 1.3309    | 1.3197    | 1.3920    | 1.4143    | 1.6356    | 1.4911    | 1.5233    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 4.05E+02            | 3.21E+02  | 5.09E+02  | 1.03E+02* | 6.64E+02  | 1.64E+01* | 4.96E+02  | 4.78E+02  | 9.96E-01* | 5.27E+02  | 8.97E+02  |         |
| 12                  | .1585     | .1638     | .1693     | .1750     | .1811     | .1876     | .1944     | .2016     | .2092     | .2172     | .2258   |
|                     | 63079.3   | 61066.9   | 59083.8   | 57130.1   | 55205.9   | 53311.4   | 51446.7   | 49611.9   | 47807.3   | 46033.0   | 44289.2 |
| 1.15E-03            | 4.51E-02  | 5.86E-04  | 5.12E-02  | 1.19E-03  | 5.17E-02  | 2.27E-02  | 2.27E-02  | 7.92E-02  | 9.30E-03  | 4.35E-02  |         |
| 1.2472              | 1.2393    | 1.3127    | 1.2877    | 1.2724    | 1.3417    | 1.3578    | 1.4059    | 1.4250    | 1.4362    | 1.5041    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 2.02E+01*           | 7.20E+02  | 8.47E+00* | 6.68E+02  | 1.40E+01* | 5.49E+02  | 2.17E+02  | 1.95E+02  | 6.07E+02  | 6.36E+01* | 2.65E+02  |         |
| 13                  | .1552     | .1602     | .1655     | .1710     | .1769     | .1830     | .1894     | .1963     | .2035     | .2111     | .2192   |
|                     | 64417.4   | 62405.0   | 60421.9   | 58468.2   | 56544.0   | 54649.5   | 52784.8   | 50950.1   | 49145.4   | 47371.1   | 45627.3 |
| 3.06E-02            | 8.52E-03  | 3.59E-02  | 9.56E-03  | 3.54E-02  | 2.06E-02  | 2.38E-02  | 4.91E-02  | 1.76E-03  | 7.40E-02  | 3.48E-02  |         |
| 1.2058              | 1.2148    | 1.2502    | 1.2598    | 1.2990    | 1.3126    | 1.3547    | 1.3709    | 1.4484    | 1.4557    | 1.4564    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 5.73E+02            | 1.45E+02* | 5.54E+02  | 1.34E+02* | 4.48E+02  | 2.35E+02  | 2.45E+02  | 4.55E+02  | 1.46E+01* | 5.51E+02  | 2.32E+02  |         |
| 14                  | .1521     | .1569     | .1620     | .1673     | .1728     | .1787     | .1849     | .1913     | .1982     | .2054     | .2130   |
|                     | 65728.9   | 63716.5   | 61733.4   | 59779.7   | 57855.5   | 55961.0   | 54096.3   | 52261.6   | 50456.9   | 48682.6   | 46938.8 |
| 3.54E-02            | 6.22E-03  | 3.12E-02  | 1.09E-02  | 3.29E-02  | 9.66E-03  | 4.33E-02  | 2.41E-03  | 5.87E-02  | 4.64E-03  | 4.94E-02  |         |
| 1.1879              | 1.2221    | 1.2296    | 1.2648    | 1.2751    | 1.3154    | 1.3256    | 1.3872    | 1.3821    | 1.3834    | 1.4473    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 7.04E+02            | 1.13E+02* | 5.15E+02  | 1.63E+02  | 4.46E+02  | 1.19E+02* | 4.80E+02  | 2.41E+01* | 5.29E+02  | 3.75E+01* | 3.58E+02  |         |
| 15                  | .1492     | .1538     | .1587     | .1638     | .1691     | .1747     | .1806     | .1868     | .1933     | .2001     | .2074   |
|                     | 67014.0   | 65001.5   | 63018.4   | 61064.7   | 59140.5   | 57246.0   | 55381.3   | 53546.6   | 51742.0   | 49967.6   | 48223.8 |
| 9.47E-03            | 5.21E-02  | 1.55E-03  | 5.81E-02  | 8.47E-05  | 4.20E-02  | 1.89E-04  | 4.60E-02  | 3.75E-03  | 4.55E-02  | 2.56E-02  |         |
| 1.1685              | 1.1987    | 1.1925    | 1.2407    | 1.1331    | 1.2865    | 1.2083    | 1.3369    | 1.3358    | 1.3938    | 1.4093    |         |
| 5.88E-03            | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |         |
| 1.98E+02*           | 6.17E+02  | 2.69E+01* | 6.08E+02  | 1.23E+00* | 5.53E+02  | 2.25E+00* | 5.02E+02  | 3.64E+01* | 3.96E+02  | 2.01E+02  |         |

Table 6. Radiative transition parameters for  $N_2 a^1\Pi_g - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units), and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . - Continued

| $V' \backslash V''$ | 0         | 1         | 2         | 3         | 4        | 5        | 6         | 7         | 8         | 9         | 10        |
|---------------------|-----------|-----------|-----------|-----------|----------|----------|-----------|-----------|-----------|-----------|-----------|
| 16                  | .1083     | .1111     | .1140     | .1171     | .1202    | .1235    | .1270     | .1305     | .1343     | .1382     | .1422     |
|                     | 92321.6   | 89991.3   | 87689.7   | 85416.9   | 83172.8  | 80957.5  | 78771.1   | 76613.5   | 74484.8   | 72385.0   | 70314.3   |
|                     | 1.82E-04  | 2.59E-03  | 1.46E-02  | 3.97E-02  | 4.96E-02 | 1.68E-02 | 2.93E-03  | 3.41E-02  | 1.47E-02  | 6.94E-03  | 3.30E-02  |
|                     | .9618     | .9791     | .9966     | 1.0145    | 1.0329   | 1.0532   | 1.0593    | 1.0859    | 1.1090    | 1.1173    | 1.1443    |
|                     | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 1.01E+01* | 1.32E+02* | 6.88E+02  | 1.73E+03  | 2.00E+03 | 6.23E+02 | 1.00E+02* | 1.07E+03  | 4.24E+02  | 1.84E+02* | 8.04E+02  |
| 17                  | .1069     | .1096     | .1125     | .1154     | .1185    | .1217    | .1250     | .1285     | .1321     | .1358     | .1398     |
|                     | 93554.2   | 91223.8   | 88922.2   | 86649.4   | 84405.4  | 82190.1  | 80003.6   | 77846.0   | 75717.3   | 73617.6   | 71546.8   |
|                     | 9.16E-05  | 1.44E-03  | 9.17E-03  | 2.96E-02  | 4.80E-02 | 2.99E-02 | 4.20E-04  | 2.08E-02  | 2.91E-02  | 2.02E-04  | 2.53E-02  |
|                     | .9530     | .9700     | .9873     | 1.0049    | 1.0229   | 1.0420   | 1.0821    | 1.0737    | 1.0956    | 1.1563    | 1.1302    |
|                     | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 5.25E+00* | 7.66E+01* | 4.52E+02* | 1.35E+03  | 2.02E+03 | 1.16E+03 | 1.51E+01* | 6.89E+02  | 8.84E+02  | 5.64E+00* | 6.49E+02  |
| 18                  | .1055     | .1082     | .1110     | .1138     | .1168    | .1199    | .1231     | .1265     | .1300     | .1336     | .1375     |
|                     | 94760.7   | 92430.4   | 90128.8   | 87856.0   | 85611.9  | 83396.6  | 81210.2   | 79052.6   | 76923.9   | 74824.1   | 72753.4   |
|                     | 4.61E-05  | 7.92E-04  | 5.64E-03  | 2.10E-02  | 4.20E-02 | 3.88E-02 | 7.19E-03  | 7.11E-03  | 3.20E-02  | 9.54E-03  | 8.08E-03  |
|                     | .9445     | .9613     | .9783     | .9956     | 1.0133   | 1.0317   | 1.0534    | 1.0605    | 1.0836    | 1.1072    | 1.1148    |
|                     | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 2.75E+00* | 4.38E+01* | 2.89E+02* | 9.98E+02  | 1.85E+03 | 1.58E+03 | 2.70E+02* | 2.46E+02* | 1.02E+03  | 2.80E+02* | 2.18E+02* |
| 19                  | .1042     | .1068     | .1095     | .1123     | .1152    | .1182    | .1214     | .1246     | .1280     | .1316     | .1353     |
|                     | 95941.5   | 93611.1   | 91309.5   | 89036.7   | 86792.6  | 84577.4  | 82390.9   | 80233.3   | 78104.6   | 76004.8   | 73934.1   |
|                     | 2.32E-05  | 4.34E-04  | 3.40E-03  | 1.44E-02  | 3.42E-02 | 4.21E-02 | 1.79E-02  | 3.42E-04  | 2.37E-02  | 2.27E-02  | 1.62E-05  |
|                     | .9363     | .9528     | .9696     | .9867     | 1.0041   | 1.0220   | 1.0415    | 1.0291    | 1.0721    | 1.0936    | .9604     |
|                     | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 1.44E+00* | 2.49E+01* | 1.82E+02* | 7.11E+02  | 1.56E+03 | 1.78E+03 | 7.01E+02  | 1.24E+01* | 7.91E+02  | 6.98E+02  | 4.59E-01* |
| 20                  | .1030     | .1055     | .1081     | .1109     | .1137    | .1166    | .1197     | .1229     | .1262     | .1296     | .1332     |
|                     | 97096.5   | 94766.2   | 92464.6   | 90191.8   | 87947.7  | 85732.5  | 83546.0   | 81388.4   | 79259.7   | 77159.9   | 75089.2   |
|                     | 1.18E-05  | 2.37E-04  | 2.03E-03  | 9.57E-03  | 2.63E-02 | 4.05E-02 | 2.77E-02  | 1.84E-03  | 1.16E-02  | 2.87E-02  | 5.46E-03  |
|                     | .9285     | .9448     | .9613     | .9781     | .9952    | 1.0128   | 1.0312    | 1.0581    | 1.0604    | 1.0820    | 1.1068    |
|                     | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 7.57E-01* | 1.41E+01* | 1.12E+02* | 4.92E+02* | 1.25E+03 | 1.79E+03 | 1.13E+03  | 6.95E+01* | 4.05E+02  | 9.22E+02  | 1.62E+02* |
| 21                  | .1018     | .1043     | .1068     | .1095     | .1123    | .1151    | .1181     | .1212     | .1244     | .1277     | .1312     |
|                     | 98226.2   | 95895.8   | 93594.2   | 91321.4   | 89077.4  | 86862.1  | 84675.6   | 82518.0   | 80389.3   | 78289.6   | 76218.8   |
|                     | 6.04E-06  | 1.29E-04  | 1.20E-03  | 6.23E-03  | 1.94E-02 | 3.58E-02 | 3.38E-02  | 8.81E-03  | 2.70E-03  | 2.49E-02  | 1.66E-02  |
|                     | .9211     | .9370     | .9533     | .9698     | .9867    | 1.0039   | 1.0218    | 1.0423    | 1.0455    | 1.0711    | 1.0925    |
|                     | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03 | 5.88E-03 | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  | 5.88E-03  |
|                     | 4.01E-01* | 7.99E+00* | 6.89E+01* | 3.33E+02* | 9.63E+02 | 1.64E+03 | 1.44E+03  | 3.47E+02* | 9.84E+01* | 8.38E+02  | 5.16E+02  |

Table 6. Radiative transition parameters for  $N_2$   $a^1\Pi_g - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units), and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 11        | 12        | 13        | 14        | 15        | 16        | 17        | 18        | 19        | 20        | 21        |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 16                  | .1465     | .1509     | .1556     | .1605     | .1656     | .1709     | .1766     | .1825     | .1887     | .1952     | .2021     |
|                     | 68272.7   | 66260.3   | 64277.1   | 62323.4   | 60399.2   | 58504.7   | 56640.0   | 54805.3   | 53000.7   | 51226.3   | 49482.5   |
|                     | 8.64E-04  | 2.87E-02  | 1.12E-02  | 1.86E-02  | 2.19E-02  | 1.28E-02  | 2.81E-02  | 1.34E-02  | 2.89E-02  | 2.31E-02  | 2.03E-02  |
|                     | 1.1907    | 1.1817    | 1.2121    | 1.2205    | 1.2527    | 1.2617    | 1.2984    | 1.3080    | 1.3493    | 1.3618    | 1.4083    |
|                     | 5.88E-03  |
|                     | 1.93E+01* | 5.84E+02  | 2.09E+02  | 3.15E+02  | 3.38E+02  | 1.80E+02  | 3.57E+02  | 1.55E+02  | 3.02E+02  | 2.18E+02  | 1.73E+02  |
| 17                  | .1439     | .1482     | .1526     | .1573     | .1623     | .1674     | .1728     | .1785     | .1844     | .1906     | .1972     |
|                     | 69505.2   | 67492.8   | 65509.7   | 63556.0   | 61631.8   | 59737.3   | 57872.6   | 56037.8   | 54233.2   | 52458.9   | 50715.1   |
|                     | 1.67E-02  | 6.36E-03  | 3.09E-02  | 2.41E-10  | 3.30E-02  | 3.12E-03  | 3.14E-02  | 7.16E-03  | 3.31E-02  | 7.32E-03  | 4.20E-02  |
|                     | 1.1555    | 1.1619    | 1.1926    | -63.3420  | 1.2326    | 1.2755    | 1.2757    | 1.3164    | 1.3227    | 1.3690    | 1.3752    |
|                     | 5.88E-03  |
|                     | 3.93E+02  | 1.37E+02* | 6.08E+02  | 4.33E-06* | 5.42E+02  | 4.66E+01* | 4.27E+02  | 8.82E+01* | 3.70E+02  | 7.40E+01* | 3.84E+02  |
| 18                  | .1414     | .1456     | .1499     | .1544     | .1591     | .1641     | .1693     | .1747     | .1804     | .1863     | .1926     |
|                     | 70711.8   | 68699.3   | 66716.2   | 64762.5   | 62838.3   | 60943.8   | 59079.1   | 57244.4   | 55439.8   | 53665.4   | 51921.6   |
|                     | 2.93E-02  | 1.09E-03  | 2.35E-02  | 1.44E-02  | 9.98E-03  | 2.73E-02  | 2.37E-03  | 3.45E-02  | 3.06E-04  | 3.93E-02  | 2.20E-04  |
|                     | 1.1406    | 1.1827    | 1.1765    | 1.2052    | 1.2116    | 1.2442    | 1.2400    | 1.2874    | 1.2306    | 1.3347    | 1.2471    |
|                     | 5.88E-03  |
|                     | 7.27E+02  | 2.47E+01* | 4.89E+02  | 2.74E+02  | 1.73E+02* | 4.34E+02  | 3.42E+01* | 4.53E+02  | 3.65E+00* | 4.26E+02  | 2.16E+00* |
| 19                  | .1391     | .1431     | .1473     | .1516     | .1562     | .1610     | .1659     | .1712     | .1766     | .1823     | .1883     |
|                     | 71892.5   | 69880.1   | 67897.0   | 65943.2   | 64019.1   | 62124.6   | 60259.8   | 58425.1   | 56620.5   | 54846.2   | 53102.3   |
|                     | 2.40E-02  | 1.47E-02  | 4.78E-03  | 2.85E-02  | 6.91E-04  | 2.60E-02  | 9.44E-03  | 1.77E-02  | 1.97E-02  | 1.21E-02  | 2.69E-02  |
|                     | 1.1271    | 1.1521    | 1.1566    | 1.1877    | 1.2440    | 1.2256    | 1.2592    | 1.2653    | 1.3003    | 1.3072    | 1.3474    |
|                     | 5.88E-03  |
|                     | 6.24E+02  | 3.51E+02  | 1.05E+02* | 5.73E+02  | 1.27E+01* | 4.37E+02  | 1.45E+02* | 2.47E+02  | 2.51E+02  | 1.39E+02  | 2.83E+02  |
| 20                  | .1369     | .1408     | .1448     | .1490     | .1534     | .1580     | .1628     | .1678     | .1731     | .1786     | .1843     |
|                     | 73047.6   | 71035.2   | 69052.0   | 67098.3   | 65174.1   | 63279.6   | 61414.9   | 59580.2   | 57775.6   | 56001.3   | 54257.4   |
|                     | 9.51E-03  | 2.60E-02  | 9.87E-04  | 2.00E-02  | 1.58E-02  | 5.09E-03  | 2.80E-02  | 4.22E-06  | 3.02E-02  | 3.34E-03  | 2.85E-02  |
|                     | 1.1130    | 1.1377    | 1.1796    | 1.1722    | 1.1999    | 1.2026    | 1.2373    | 1.8198    | 1.2782    | 1.3242    | 1.3223    |
|                     | 5.88E-03  |
|                     | 2.60E+02* | 6.52E+02  | 2.28E+01* | 4.22E+02  | 3.05E+02  | 9.03E+01* | 4.54E+02  | 6.26E-02* | 4.09E+02  | 4.11E+01* | 3.19E+02  |
| 21                  | .1348     | .1386     | .1425     | .1466     | .1508     | .1553     | .1599     | .1647     | .1698     | .1750     | .1805     |
|                     | 74177.2   | 72164.8   | 70181.7   | 68228.0   | 66303.8   | 64409.3   | 62544.6   | 60709.8   | 58905.2   | 57130.9   | 55387.1   |
|                     | 5.12E-04  | 2.30E-02  | 1.23E-02  | 4.13E-03  | 2.59E-02  | 1.77E-03  | 1.98E-02  | 1.44E-02  | 7.95E-03  | 2.63E-02  | 1.35E-03  |
|                     | 1.0820    | 1.1249    | 1.1496    | 1.1528    | 1.1837    | 1.2250    | 1.2196    | 1.2506    | 1.2543    | 1.2904    | 1.2740    |
|                     | 5.88E-03  |
|                     | 1.46E+01* | 6.05E+02  | 2.98E+02  | 9.19E+01* | 5.29E+02  | 3.30E+01* | 3.39E+02  | 2.25E+02  | 1.14E+02* | 3.44E+02  | 1.61E+01* |

\*The Einstein coefficient for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 7. Radiative transition parameters for  $N_2$   $a^1\Pi_g - a'^1\Sigma_u^-$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $V' \backslash V''$ | 0           | 1           | 2           | 3          | 4          | 5          | 6          | 7          | 8          | 9          | 10       |
|---------------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|----------|
| 0                   | 8.2515      | -33.9751    | -5.6281     | -3.0905    | -2.1408    | -1.6437    | -1.3381    | -1.1312    | -.9819     | -.8691     | -.7808   |
|                     | 1211.9      | -294.3      | -1776.8     | -3235.7    | -4671.3    | -6083.7    | -7473.3    | -8840.2    | -10184.6   | -11506.7   | -12806.7 |
| 6.01E-01            | 2.81E-01    | 8.75E-02    | 2.32E-02    | 5.70E-03   | 1.36E-03   | 3.19E-04   | 7.55E-05   | 1.81E-05   | 4.42E-06   | 1.11E-06   |          |
| 1.2527              | 1.2008      | 1.1576      | 1.1203      | 1.0876     | 1.0583     | 1.0318     | 1.0078     | .9859      | .9657      | .9473      |          |
| 2.12E-01            | 2.28E-01    | 2.42E-01    | 2.53E-01    | 2.63E-01   | 2.72E-01   | 2.79E-01   | 2.86E-01   | 2.92E-01   | 2.97E-01   | 3.01E-01   |          |
| 9.74E+01            | -1.51E+00   | -1.16E+02   | -2.04E+02   | -1.63E+02  | -9.13E+01  | -4.21E+01  | -1.73E+01  | -6.59E+00  | -2.40E+00  | -8.53E-01  |          |
| 9.74E+01            | -1.51E+00   | -1.17E+02   | -2.05E+02   | -1.64E+02* | -9.20E+01* | -4.25E+01* | -1.75E+01* | -6.67E+00* | -2.43E+00* | -8.66E-01* |          |
| 1                   | 3.4743      | 7.2886      | -90.5412    | -6.3721    | -3.3279    | -2.2638    | -1.7221    | -1.3940    | -1.1739    | -1.0162    | -.8976   |
|                     | 2878.2      | 1372.0      | -110.4      | -1569.3    | -3004.9    | -4417.4    | -5807.0    | -7173.9    | -8518.3    | -9840.4    | -11140.3 |
| 3.30E+01            | 1.47E+01    | 2.78E+01    | 1.57E+01    | 6.04E+02   | 1.95E+02   | 5.75E+03   | 1.62E+03   | 4.45E+04   | 1.22E+04   | 3.34E+05   |          |
| 1.3101              | 1.2688      | 1.2095      | 1.1648      | 1.1269     | 1.0938     | 1.0643     | 1.0378     | 1.0137     | .9917      | .9715      |          |
| 1.94E+01            | 2.07E+01    | 2.26E+01    | 2.40E+01    | 2.51E+01   | 2.61E+01   | 2.70E+01   | 2.78E+01   | 2.84E+01   | 2.90E+01   | 2.95E+01   |          |
| 5.98E+02            | 3.30E+01    | -7.74E+02   | -1.41E+02   | -4.20E+02  | -4.66E+02  | -3.33E+02  | -1.87E+02  | -9.01E+01  | -3.95E+01  | -1.63E+01  |          |
| 5.98E+02            | 3.30E+01    | -7.74E+02   | -1.41E+02   | -4.21E+02  | -4.67E+02  | -3.35E+02* | -1.88E+02* | -9.10E+01* | -4.00E+01* | -1.65E+01* |          |
| 2                   | 2.2140      | 5.5217      | 6.5442      | 144.5651   | -7.3185    | -3.5986    | -2.3990    | -1.8066    | -1.4535    | -1.2192    | -1.0524  |
|                     | 4516.8      | 3010.5      | 1528.1      | 69.2       | -1366.4    | -2778.9    | -4168.4    | -5535.3    | -6879.7    | -8201.8    | -9501.8  |
| 6.39E+02            | 4.06E+01    | 8.92E+03    | 1.85E+01    | 1.80E+01   | 9.62E+02   | 3.95E+02   | 1.41E+02   | 4.64E+03   | 1.46E+03   | 4.50E+04   |          |
| 1.3798              | 1.3196      | 1.3294      | 1.2196      | 1.1723     | 1.1336     | 1.1001     | 1.0705     | 1.0438     | 1.0196     | .9975      |          |
| 1.72E+01            | 1.91E+01    | 1.88E+01    | 2.23E+01    | 2.37E+01   | 2.49E+01   | 2.60E+01   | 2.68E+01   | 2.76E+01   | 2.83E+01   | 2.88E+01   |          |
| 3.52E+02            | 8.17E+02    | 2.27E+00    | 6.14E-03    | -1.05E+02  | -5.20E+02  | -7.80E+02  | -6.96E+02  | -4.66E+02  | -2.61E+02  | -1.30E+02  |          |
| 3.51E+02            | 8.17E+02    | 2.28E+00*   | 6.13E-03    | -1.05E+02  | -5.21E+02  | -7.83E+02  | -7.00E+02  | -4.69E+02* | -2.64E+02* | -1.32E+02* |          |
| 3                   | 1.6320      | 2.1639      | 3.1859      | 5.9526     | 40.9231    | -8.5609    | -3.9098    | -2.5481    | -1.8979    | -1.5172    | -1.2673  |
|                     | 6127.5      | 4621.3      | 3138.8      | 1679.9     | 244.4      | -1168.1    | -2557.7    | -3924.6    | -5269.0    | -6591.1    | -7891.1  |
| 5.25E-03            | 1.48E-01    | 3.60E-01    | 1.23E-02    | 9.04E-02   | 1.63E-01   | 1.19E-01   | 6.11E-02   | 2.59E-02   | 9.88E-03   | 3.53E-03   |          |
| 1.4705              | 1.3885      | 1.3300      | 1.2070      | 1.2329     | 1.1804     | 1.1406     | 1.1066     | 1.0766     | 1.0498     | 1.0255     |          |
| 1.45E+01            | 1.69E+01    | 1.87E+01    | 2.26E+01    | 2.18E+01   | 2.35E+01   | 2.47E+01   | 2.58E+01   | 2.66E+01   | 2.74E+01   | 2.81E+01   |          |
| 5.13E+01            | 8.45E+02    | 7.92E+02    | 6.06E+00    | 1.27E-01   | -5.81E+01  | -4.95E+02  | -9.92E+02  | -1.09E+03  | -8.61E+02  | -5.54E+02  |          |
| 5.03E+01*           | 8.43E+02    | 7.94E+02    | 6.03E+00    | 1.27E-01   | -5.80E+01  | -4.95E+02  | -9.95E+02  | -1.10E+03  | -8.67E+02* | -5.59E+02* |          |
| 4                   | 1.2969      | 1.6118      | 2.1178      | 3.0647     | 5.4722     | 24.0982    | -10.2605   | -4.2708    | -2.7130    | -1.9968    | -1.5853  |
|                     | 7710.6      | 6204.4      | 4721.9      | 3263.0     | 1827.4     | 415.0      | -974.6     | -2341.5    | -3685.9    | -5008.0    | -6308.0  |
| 1.69E-04            | 1.77E-02    | 2.26E-01    | 2.68E-01    | 6.19E-02   | 2.82E-02   | 1.24E-01   | 1.26E-01   | 7.94E-02   | 3.97E-02   | 1.73E-02   |          |
| 1.6063              | 1.4796      | 1.3974      | 1.3421      | 1.2483     | 1.2562     | 1.1895     | 1.1478     | 1.1131     | 1.0829     | 1.0559     |          |
| 1.08E-01            | 1.42E-01    | 1.67E+01    | 1.84E+01    | 2.13E+01   | 2.11E+01   | 2.32E+01   | 2.45E+01   | 2.56E+01   | 2.65E+01   | 2.72E+01   |          |
| ( 1.83E+00)         | 1.73E+02    | 1.34E+03    | 6.37E+02    | 3.48E+01   | 1.82E+01   | -2.51E+01  | -3.92E+02  | -1.05E+03  | -1.41E+03  | -1.31E+03  |          |
| 1.66E+00*           | 1.70E+02    | 1.34E+03    | 6.40E+02    | 3.47E+01   | 1.81E+01   | -2.50E+01  | -3.92E+02  | -1.05E+03  | -1.42E+03  | -1.31E+03  |          |
| 5                   | 1.0792      | 1.2887      | 1.5930      | 2.0753     | 2.9560     | 5.0750     | 17.2160    | -12.7221   | -4.6939    | -2.8964    | -2.1041  |
|                     | 9266.1      | 7759.8      | 6277.4      | 4818.5     | 3382.9     | 1970.4     | 580.9      | -786.0     | -2130.4    | -3452.5    | -4752.5  |
| 1.25E-06            | 7.29E+04    | 3.73E+02    | 2.88E+01    | 1.74E+01   | 1.11E+01   | 2.10E+03   | 7.97E+02   | 1.16E+01   | 9.11E+02   | 5.32E+02   |          |
| 1.9156              | 1.6185      | 1.4890      | 1.4067      | 1.3570     | 1.2637     | 1.3609     | 1.2003     | 1.1554     | 1.1199     | 1.0892     |          |
| 4.73E-02            | 1.05E+01    | 1.39E+01    | 1.64E+01    | 1.79E+01   | 2.08E+01   | 1.78E+01   | 2.29E+01   | 2.43E+01   | 2.54E+01   | 2.63E+01   |          |
| ( 4.50E-03)         | ( 7.60E+00) | 3.63E+02    | 1.75E+03    | 4.38E+02   | 7.47E+01   | 2.63E+02   | -8.20E+00  | -2.69E+02  | -9.76E+02  | -1.60E+03  |          |
| 7.14E-04*           | 6.85E+00*   | 3.56E+02    | 1.75E+03    | 4.41E+02   | 7.45E+01   | 2.58E+02*  | -8.16E+00  | -2.68E+02  | -9.77E+02  | -1.60E+03  |          |
| 6                   | .9264       | 1.0767      | 1.2812      | 1.5757     | 2.0363     | 2.8585     | 4.7421     | 13.4790    | -16.5974   | -5.1959    | -3.1012  |
|                     | 10794.0     | 9287.8      | 7805.3      | 6346.4     | 4910.8     | 3498.4     | 2108.8     | 741.9      | -602.5     | -1924.6    | -3224.6  |
| 1.42E-09            | 6.01E-06    | 1.88E+03    | 6.27E+02    | 3.29E+01   | 9.70E+02   | 1.41E+01   | 3.49E+03   | 4.14E+02   | 9.65E+02   | 9.43E+02   |          |
| .3303               | 1.9519      | 1.6311      | 1.4985      | 1.4164     | 1.3771     | 1.2751     | 1.1300     | 1.2146     | 1.1636     | 1.1268     |          |
| 3.18E-01            | 4.23E-02    | 1.02E+01    | 1.37E+01    | 1.61E+01   | 1.73E+01   | 2.05E+01   | 2.50E+01   | 2.24E+01   | 2.40E+01   | 2.51E+01   |          |
| ( 3.67E-04)         | ( 1.75E-02) | ( 1.88E+01) | 6.07E+02    | 2.04E+03   | 2.51E+02   | 1.13E+02   | 1.81E+01   | -1.84E+00  | -1.61E+02  | -8.10E+02  |          |
| 5.40E-04*           | 1.02E+03*   | 1.69E+01*   | 5.97E+02    | 2.04E+03   | 2.55E+02   | 1.12E+02   | 1.83E+01*  | -1.83E+00  | -1.60E+02  | -8.09E+02  |          |
| 7                   | .8134       | .9269       | 1.0746      | 1.2744     | 1.5597     | 2.0005     | 2.7706     | 4.4595     | 11.1360    | -23.5783   | -5.8001  |
|                     | 12294.5     | 10788.2     | 9305.8      | 7846.9     | 6411.3     | 4998.9     | 3609.3     | 2242.4     | 898.0      | -424.1     | -1724.1  |
| 1.40E-10            | 1.52E+08    | 1.66E+05    | 3.78E+03    | 9.25E+02   | 3.49E+01   | 4.35E+02   | 1.50E+01   | 2.07E+02   | 1.51E+02   | 7.15E-02   |          |
| 1.8458              | .6611       | 1.9935      | 1.6442      | 1.5083     | 1.4266     | 1.4093     | 1.2855     | 1.1988     | 1.2390     | 1.1728     |          |
| 5.81E-02            | 3.45E+01    | 3.71E+02    | 9.87E+02    | 1.34E+01   | 1.58E+01   | 1.63E+01   | 2.02E+01   | 2.29E+01   | 2.16E+01   | 2.37E+01   |          |
| ( 1.78E-06)         | ( 4.59E-03) | ( 3.73E-02) | ( 3.61E+01) | 8.87E+02   | 2.19E+03   | 1.10E+02   | 1.39E+02   | 1.59E+00   | -2.19E+01  | -8.36E+01  |          |
| 1.70E-09*           | 3.61E-03*   | 4.48E-06*   | 3.21E+01*   | 8.72E+02   | 2.20E+03   | 1.13E+02   | 1.39E+02   | 1.59E+00   | -2.16E+01  | -8.32E+01  |          |

Table 7. Radiative transition parameters for  $N_2^+ a^- \Pi_g - a'^- \Sigma_u^-$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . – Continued

| $v' \backslash v''$ | 11         | 12         | 13         | 14         | 15         | 16         | 17         | 18         | 19         | 20         | 21       |
|---------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|----------|
| 0                   | -.7100     | -.6518     | -.6033     | -.5621     | -.5268     | -.4962     | -.4694     | -.4458     | -.4248     | -.4061     | -.3892   |
|                     | -14084.7   | -15341.0   | -16575.8   | -17789.0   | -18981.0   | -20151.8   | -21301.6   | -22430.6   | -23538.8   | -24626.3   | -25693.3 |
| 2.84E-07            | 7.48E-08   | 2.03E-08   | 5.69E-09   | 1.64E-09   | 4.84E-10   | 1.47E-10   | 4.54E-11   | 1.43E-11   | 4.52E-12   | 1.39E-12   |          |
|                     | .9304      | .9149      | .9007      | .8876      | .8753      | .8634      | .8520      | .8408      | .8298      | .8171      | .7981    |
| 3.05E-01            | 3.09E-01   | 3.12E-01   | 3.15E-01   | 3.17E-01   | 3.19E-01   | 3.22E-01   | 3.24E-01   | 3.26E-01   | 3.28E-01   | 3.31E-01   |          |
| -2.99E-01           | -1.04E-01  | -3.65E-02  | -1.28E-02  | -4.56E-03  | -1.64E-03  | -5.94E-04  | -2.17E-04  | -8.01E-05  | -2.94E-05  | -1.05E-05  |          |
| -3.04E-01*          | -1.06E-01* | -3.71E-02* | -1.31E-02* | -4.65E-03* | -1.67E-03* | -6.05E-04* | -2.22E-04* | -8.17E-05* | -3.00E-05* | -1.07E-05* |          |
| 1                   | -.8053     | -.7313     | -.6707     | -.6202     | -.5775     | -.5410     | -.5093     | -.4816     | -.4572     | -.4355     | -.4162   |
|                     | -12418.4   | -13674.7   | -14909.4   | -16122.7   | -17314.7   | -18485.5   | -19635.3   | -20764.2   | -21872.4   | -22960.0   | -24027.0 |
| 9.25E-06            | 2.61E-06   | 7.49E-07   | 2.20E-07   | 6.61E-08   | 2.04E-08   | 6.40E-09   | 2.05E-09   | 6.67E-10   | 2.18E-10   | 7.12E-11   |          |
|                     | .9530      | .9359      | .9203      | .9059      | .8927      | .8804      | .8687      | .8571      | .8449      | .8313      | .8151    |
| 3.00E-01            | 3.04E-01   | 3.07E-01   | 3.11E-01   | 3.14E-01   | 3.16E-01   | 3.18E-01   | 3.21E-01   | 3.23E-01   | 3.25E-01   | 3.28E-01   |          |
| -6.46E+00           | -2.49E+00  | -9.51E+00  | -3.61E+01  | -1.37E+01  | -5.20E+02  | -1.99E+02  | -7.65E+03  | -2.95E+03  | -1.13E+03  | -4.31E+04  |          |
| -6.55E+00*          | -2.53E+00* | -9.66E+01* | -3.67E+01* | -1.39E+01* | -5.30E+02* | -2.03E+02* | -7.80E+03* | -3.01E+03* | -1.16E+03* | -4.42E+04* |          |
| 2                   | -.9277     | -.8308     | -.7535     | -.6904     | -.6379     | -.5936     | -.5557     | -.5229     | -.4942     | -.4690     | -.4467   |
|                     | -10779.9   | -12036.2   | -13270.9   | -14484.2   | -15676.1   | -16847.0   | -17996.8   | -19125.7   | -20233.9   | -21321.4   | -22388.4 |
| 1.37E-04            | 4.19E-05   | 1.29E-05   | 4.01E-06   | 1.27E-06   | 4.07E-07   | 1.33E-07   | 4.43E-08   | 1.50E-08   | 5.14E-09   | 1.77E-09   |          |
|                     | .9773      | .9587      | .9416      | .9258      | .9113      | .8978      | .8852      | .8732      | .8615      | .8496      | .8364    |
| 2.94E-01            | 2.98E-01   | 3.03E-01   | 3.06E-01   | 3.10E-01   | 3.12E-01   | 3.15E-01   | 3.18E-01   | 3.20E-01   | 3.22E-01   | 3.24E-01   |          |
| -6.02E+01           | -2.64E+01  | -1.12E+01  | -4.63E+00  | -1.89E+00  | -7.70E+01  | -3.12E+01  | -1.27E+01  | -5.15E+02  | -2.09E+02  | -8.46E+03  |          |
| -6.09E+01*          | -2.67E+01* | -1.13E+01* | -4.70E+00* | -1.92E+00* | -7.83E+01* | -3.18E+01* | -1.29E+01* | -5.25E+02* | -2.13E+02* | -8.65E+03* |          |
| 3                   | -1.0906    | -.9592     | -.8576     | -.7768     | -.7110     | -.6563     | -.6103     | -.5709     | -.5370     | -.5073     | -.4813   |
|                     | -9169.1    | -10425.4   | -11660.1   | -12873.4   | -14065.4   | -15236.2   | -16386.0   | -17515.0   | -18623.1   | -19710.7   | -20777.7 |
| 1.21E-03            | 4.08E-04   | 1.36E-04   | 4.54E-05   | 1.52E-05   | 5.14E-06   | 1.76E-06   | 6.11E-07   | 2.15E-07   | 7.65E-08   | 2.75E-08   |          |
|                     | 1.0034     | .9831      | .9645      | .9473      | .9314      | .9167      | .9030      | .8902      | .8781      | .8662      | .8540    |
| 2.87E-01            | 2.92E-01   | 2.97E-01   | 3.01E-01   | 3.05E-01   | 3.08E-01   | 3.11E-01   | 3.14E-01   | 3.17E-01   | 3.19E-01   | 3.21E-01   |          |
| -3.12E+02           | -1.60E+02  | -7.71E+01  | -3.56E+01  | -1.59E+01  | -7.01E+00  | -3.04E+00  | -1.31E+00  | -5.64E+01  | -2.42E+01  | -1.03E+01  |          |
| -3.15E+02*          | -1.62E+02* | -7.81E+01* | -3.61E+01* | -1.62E+01* | -7.12E+00* | -3.09E+00* | -1.33E+00* | -5.74E+01* | -2.46E+01* | -1.05E+01* |          |
| 4                   | -1.3182    | -1.1309    | -.9924     | -.8857     | -.8011     | -.7324     | -.6755     | -.6277     | -.5869     | -.5516     | -.5210   |
|                     | -7586.1    | -8842.4    | -10077.1   | -11290.3   | -12482.3   | -13653.1   | -14802.9   | -15931.9   | -17040.1   | -18127.6   | -19194.6 |
| 6.95E-03            | 2.65E-03   | 9.77E-04   | 3.54E-04   | 1.27E-04   | 4.58E-05   | 1.65E-05   | 6.01E-06   | 2.21E-06   | 8.17E-07   | 3.05E-07   |          |
|                     | 1.0315     | 1.0093     | .9889      | .9702      | .9529      | .9370      | .9221      | .9083      | .8954      | .8830      | .8709    |
| 2.79E-01            | 2.85E-01   | 2.91E-01   | 2.96E-01   | 3.00E-01   | 3.04E-01   | 3.07E-01   | 3.10E-01   | 3.13E-01   | 3.16E-01   | 3.18E-01   |          |
| -9.59E+02           | -6.04E+02  | -3.42E+02  | -1.80E+02  | -9.03E+01  | -4.36E+01  | -2.05E+01  | -9.48E+00  | -4.33E+00  | -1.96E+00  | -8.85E+01  |          |
| -9.66E+02*          | -6.09E+02* | -3.46E+02* | -1.83E+02* | -9.15E+01* | -4.42E+01* | -2.08E+01* | -9.63E+00* | -4.40E+00* | -2.00E+00* | -9.01E+01* |          |
| 5                   | -1.6582    | 1.3723     | 1.1735     | 1.0272     | -.9152     | -.8266     | -.7549     | -.6956     | -.6458     | -.6034     | -.5669   |
|                     | -6030.6    | -7286.9    | -8521.6    | -9734.9    | -10926.8   | -12097.7   | -13247.5   | -14376.4   | -15484.6   | -16572.1   | -17639.2 |
| 2.64E-02            | 1.18E-02   | 4.96E-03   | 2.00E-03   | 7.83E-04   | 3.03E-04   | 1.16E-04   | 4.47E-05   | 1.72E-05   | 6.66E-06   | 2.59E-06   |          |
|                     | 1.0620     | 1.0375     | 1.0152     | .9948      | .9760      | .9586      | .9426      | .9276      | .9137      | .9006      | .8880    |
| 2.71E-01            | 2.78E-01   | 2.84E-01   | 2.89E-01   | 2.94E-01   | 2.98E-01   | 3.02E-01   | 3.06E-01   | 3.09E-01   | 3.12E-01   | 3.15E-01   |          |
| -1.72E+03           | -1.43E+03  | -1.00E+03  | -6.24E+02  | -3.58E+02  | -1.94E+02  | -1.00E+02  | -5.03E+01  | -2.47E+01  | -1.19E+01  | -5.70E+00  |          |
| -1.73E+03           | -1.44E+03  | -1.01E+03* | -6.30E+02* | -3.62E+02* | -1.96E+02* | -1.02E+02* | -5.10E+01* | -2.51E+01* | -1.21E+01* | -5.80E+00* |          |
| 6                   | -2.2209    | -1.7364    | -1.4299    | -1.2185    | -1.0640    | -9.461     | -8.533     | -7.783     | -7.165     | -6.647     | -6.207   |
|                     | -4502.7    | -5759.0    | -6993.7    | -8206.9    | -9398.9    | -10569.7   | -11719.6   | -12848.5   | -13956.7   | -15044.2   | -16111.2 |
| 6.44E-02            | 3.61E-02   | 1.80E-02   | 8.26E-03   | 3.61E-03   | 1.53E-03   | 6.33E-04   | 2.59E-04   | 1.05E-04   | 4.28E-05   | 1.74E-05   |          |
|                     | 1.0956     | 1.0682     | 1.0435     | 1.0211     | 1.0006     | .9818      | .9644      | .9482      | .9332      | .9191      | .9059    |
| 2.61E-01            | 2.69E-01   | 2.76E-01   | 2.82E-01   | 2.88E-01   | 2.93E-01   | 2.97E-01   | 3.01E-01   | 3.05E-01   | 3.08E-01   | 3.11E-01   |          |
| -1.62E+03           | -2.02E+03  | -1.90E+03  | -1.47E+03  | -1.01E+03  | -6.26E+02  | -3.64E+02  | -2.02E+02  | -1.08E+02  | -5.60E+01  | -2.85E+01  |          |
| -1.62E+03           | -2.03E+03  | -1.91E+03  | -1.48E+03* | -1.01E+03* | -6.32E+02* | -3.68E+02* | -2.04E+02* | -1.09E+02* | -5.68E+01* | -2.90E+01* |          |
| 7                   | -3.3309    | -2.3483    | -1.8204    | -1.4911    | -1.2661    | -1.1026    | -9.9786    | -8.8812    | -8.028     | -7.7383    | -7.6844  |
|                     | -3002.2    | -4258.5    | -5493.2    | -6706.4    | -7898.4    | -9069.2    | -10219.1   | -11348.0   | -12456.2   | -13543.7   | -14610.7 |
| 8.94E-02            | 7.15E-02   | 4.53E-02   | 2.49E-02   | 1.25E-02   | 5.92E-03   | 2.69E-03   | 1.19E-03   | 5.17E-04   | 2.23E-04   | 9.54E-05   |          |
|                     | 1.1340     | 1.1022     | 1.0744     | 1.0496     | 1.0271     | 1.0065     | .9876      | .9701      | .9539      | .9388      | .9246    |
| 2.49E-01            | 2.59E-01   | 2.67E-01   | 2.74E-01   | 2.81E-01   | 2.86E-01   | 2.91E-01   | 2.96E-01   | 3.00E-01   | 3.03E-01   | 3.07E-01   |          |
| -6.09E+02           | -1.50E+03  | -2.17E+03  | -2.29E+03  | -1.97E+03  | -1.46E+03  | -9.85E+02  | -6.15E+02  | -3.63E+02  | -2.06E+02  | -1.13E+02  |          |
| -6.08E+02           | -1.50E+03  | -2.18E+03  | -2.30E+03  | -1.98E+03  | -1.48E+03* | -9.95E+02* | -6.22E+02* | -3.68E+02* | -2.09E+02* | -1.15E+02* |          |

Table 7. Radiative transition parameters for  $N_2$   $a^1\Pi_g - a'^1\Sigma_u^-$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| $v' \backslash v''$ | 0   | 1   | 2   | 3  | 4                                 | 5         | 6           | 7         | 8         | 9         | 10         |
|---------------------|---|---|---|--|-----------------------------------|-----------|-------------|-----------|-----------|-----------|------------|
| 8                   | .7263   | .8156   | .9277   | 1.0730   | 1.2683                            | 1.5451    | 1.9676      | 2.6914    | 4.2174    | 9.5326    | -39.8459   |
|                     | 13767.6   | 12261.4   | 10778.9   | 9320.0   | 7884.5                            | 6472.0    | 5082.4      | 3715.5    | 2371.1    | 1049.0    | -251.0     |
|                     | 8.90E-13  | 9.87E-10  | 8.36E-08  | 3.42E-05   | 6.48E-03                          | 1.25E-01  | 3.52E-01    | 1.28E-02  | 1.41E-01  | 4.34E-02  | 2.13E-03   |
|                     | .8519   | 1.9181  | .8785   | 2.0421   | 1.6578                            | 1.5184    | 1.4373      | 1.4805    | 1.2958    | 1.2196    | 1.3203     |
|                     | 3.22E-01  | 4.69E-02  | 3.16E-01  | 3.17E-02   | 9.56E-02                          | 1.31E-01  | 1.55E-01    | 1.42E-01  | 1.98E-01  | 2.23E-01  | 1.91E-01   |
|                     | ( 4.87E-07)( 8.11E-06)( 2.12E-02)   | ( 5.62E-02)( 5.88E+01)  |   | 1.18E+03   | 2.23E+03                          | 2.67E+01  | 1.49E+02    | 5.03E+00  | -4.95E-03 |           |            |
|                     | 3.21E-07*   | 1.05E-06*   | 1.35E-02*   | 6.69E-03*  | 5.18E+01*                         | 1.16E+03  | 2.25E+03    | 2.81E+01  | 1.49E+02  | 5.02E+00  | -4.81E-03* |
| 9                   | .6573   | .7295   | .8180   | .9289  | 1.0718                            | 1.2630    | 1.5318      | 1.9374    | 2.6198    | 4.0081    | 8.3686     |
|                     | 15213.5   | 13707.3   | 12224.8   | 10765.9  | 9330.4                            | 7917.9    | 6528.3      | 5161.4    | 3817.0    | 2494.9    | 1194.9     |
|                     | 1.77E-14  | 1.22E-11  | 3.78E-09  | 3.22E-07   | 5.81E-05                          | 9.99E-03  | 1.58E-01    | 3.41E-01  | 7.54E-04  | 1.20E-01  | 6.43E-02   |
|                     | 2.3696  | 1.0336  | 2.0006  | 1.0362   | 2.1001                            | 1.6719    | 1.5287      | 1.4488    | 1.9240    | 1.3066    | 1.2327     |
|                     | 9.44E-03  | 2.79E-01  | 3.63E-02  | 2.78E-01   | 2.60E-02                          | 9.23E-02  | 1.28E-01    | 1.51E-01  | 4.61E-02  | 1.95E-01  | 2.18E-01   |
|                     | ( 1.13E-11)( 4.93E-06)  | 1.84E-05  | ( 6.28E-02)( 6.47E-02)( 8.56E+01)                       |  | 1.47E+03                          | 2.17E+03  | ( 1.81E-01) | 1.44E+02  | 1.06E+01  |           |            |
|                     | 3.64E-09*   | 2.89E-06*   | 2.02E-05*   | 3.72E-02*  | 5.65E-02*                         | 7.47E+01* | 1.45E+03    | 2.19E+03  | 5.72E-02* | 1.44E+02  | 1.06E+01   |
| 10                  | .6012   | .6611   | .7329   | .8207  | .9503                             | 1.0710    | 1.2583      | 1.5197    | 1.9099    | 2.5551    | 3.8260     |
|                     | 16632.3   | 15126.1   | 13643.6   | 12184.7  | 10749.1                           | 9336.7    | 7947.1      | 6580.2    | 5235.8    | 3913.7    | 2613.7     |
|                     | 3.93E-17  | 6.19E-14  | 7.94E-11  | 1.02E-08   | 9.75E-07                          | 8.52E-05  | 1.42E-02    | 1.91E-01  | 3.22E-01  | 2.20E-03  | 9.48E-02   |
|                     | 2.5371  | 3.2137  | 1.1629  | 2.1031   | 1.1572                            | 2.1709    | 1.6867      | 1.5394    | 1.4611    | 1.0159    | 1.3185     |
|                     | 4.62E-03  | 1.34E-04  | 2.40E-01  | 2.57E-02   | 2.42E-01                          | 2.03E-02  | 8.90E-02    | 1.25E-01  | 1.47E-01  | 2.84E-01  | 1.91E-01   |
|                     | ( 7.83E-15)( 7.80E-15)( 2.36E-05)( 2.48E-05)( 1.44E-01)( 5.76E-02)( 1.14E+02) |   |   |  | 1.74E+03                          | 2.04E+03  | ( 2.15E+01) | 1.25E+02  |           |           |            |
|                     | 1.02E-10*   | 8.16E-08*   | 1.29E-05*   | 1.55E-04*  | 8.34E-02*                         | 2.31E-01* | 9.88E+01    | 1.72E+03  | 2.07E+03  | 1.94E+01* | 1.25E+02   |
| 11                  | .5548   | .6054   | .6651   | .7366  | .8237                             | .9321     | 1.0708      | 1.2544    | 1.5088    | 1.8848    | 2.4966     |
|                     | 18024.1   | 16517.8   | 15035.4   | 13576.5  | 12140.9                           | 10728.4   | 9338.9      | 7972.0    | 6627.6    | 5305.5    | 4005.5     |
|                     | 1.32E-15  | 8.13E-15  | 2.00E-13  | 3.62E-10   | 2.14E-08                          | 2.50E-06  | 1.10E-04    | 1.90E-02  | 2.23E-01  | 2.97E-01  | 1.21E-02   |
|                     | 1.3209  | 1.7196  | 3.8656  | 1.2709   | 2.2336                            | 1.2552    | 2.2607      | 1.7021    | 1.5503    | 1.4744    | 1.2161     |
|                     | 1.90E-01  | 8.19E-02  | 1.63E-06  | 2.06E-01   | 1.61E-02                          | 2.11E-01  | 1.45E-02    | 8.56E-02  | 1.22E-01  | 1.44E-01  | 2.24E-01   |
|                     | 5.69E-10  | ( 4.97E-10)( 3.68E-18)( 7.81E-05)( 2.01E-05)( 2.78E-01)( 3.83E-02)( 1.43E+02)                       |   |  |                                   |           | 1.98E+03    | 1.85E+03  | 7.87E+01  |           |            |
|                     | 5.90E-10*   | 1.87E-11*   | 5.19E-07*   | 4.01E-05*  | 7.42E-04*                         | 1.61E-01* | 6.76E-01*   | 1.22E+02  | 1.96E+03  | 1.89E+03  | 7.31E+01   |
| 12                  | .5158   | .5592   | .6097   | .6693  | .7404                             | .8269     | .9343       | 1.0710    | 1.2512    | 1.4992    | 1.8621     |
|                     | 19388.9   | 17882.7   | 16400.3   | 14941.4  | 13505.8                           | 12093.3   | 10703.7     | 9336.9    | 7992.5    | 6670.3    | 5370.4     |
|                     | 1.46E-16  | 1.71E-16  | 7.81E-14  | 1.28E-13   | 1.30E-09                          | 3.63E-08  | 5.60E-06    | 1.27E-04  | 2.43E-02  | 2.54E-01  | 2.69E-01   |
|                     | .12686  | .9205   | 1.7458  | 7.7711   | 1.3647                            | 2.4136    | 1.3378      | 2.3796    | 1.7183    | 1.5615    | 1.4889     |
|                     | 2.07E-01  | 3.07E-01  | 7.65E-02  | 7.17E-27   | 1.77E-01                          | 7.88E-03  | 1.85E-01    | 9.06E-03  | 8.21E-02  | 1.19E-01  | 1.39E-01   |
|                     | 9.22E-11  | ( 1.87E-10)( 4.08E-09)( 0.00E+00)   | 2.03E-04*   | 8.07E-06*  | ( 4.76E-01)( 1.72E-02)( 1.69E+02) |           |             | 2.18E+03  | 1.64E+03  |           |            |
|                     | 8.79E-11*   | 1.37E-10*   | 4.79E-11*   | 2.66E-06*  | 9.70E-05*                         | 2.68E-03* | 2.74E-01*   | 1.61E+00* | 1.42E+02  | 2.16E+03  | 1.69E+03   |
| 13                  | .4825   | .5203   | .5637   | .6143  | .6737                             | .7445     | .8304       | .9368     | 1.0717    | 1.2487    | 1.4907     |
|                     | 20727.1   | 19220.8   | 17738.4   | 16279.5  | 14843.9                           | 13431.4   | 12041.9     | 10675.0   | 9330.6    | 8008.5    | 6708.5     |
|                     | 4.61E-16  | 1.45E-16  | 1.93E-16  | 2.83E-13   | 1.52E-13                          | 3.87E-09  | 4.92E-08    | 1.13E-05  | 1.29E-04  | 2.97E-02  | 2.82E-01   |
|                     | 1.2920  | 1.2086  | .7697   | 1.9307   | -9.2188                           | 1.4500    | 2.6883      | 1.4100    | 2.5474    | 1.7353    | 1.5731     |
|                     | 1.99E-01  | 2.26E-01  | 3.35E-01  | 4.52E-02   | 0.00E+00                          | 1.51E-01  | 2.30E-03    | 1.63E-01  | 4.42E-03  | 7.86E-02  | 1.16E-01   |
|                     | 3.31E-10  | ( 1.06E-10)( 2.45E-10)( 5.05E-09)( 0.00E+00)( 4.32E-04)( 9.17E-07)( 7.38E-01)( 4.13E-03)( 1.91E+02) |   |  |                                   |           |             | 2.34E+03  |           |           |            |
|                     | 3.35E-10*   | 1.21E-10*   | 7.63E-11*   | 1.26E-08*  | 1.03E-05*                         | 1.86E-04* | 7.95E-03*   | 4.20E-01* | 3.35E+00* | 1.57E+02  | 2.33E+03   |
| 14                  | .4538   | .4870   | .5249   | .5685  | .6190                             | .6783     | .7489       | .8343     | .9397     | 1.0730    | 1.2469     |
|                     | 22038.6   | 20532.3   | 19049.9   | 17591.0  | 16155.4                           | 14742.9   | 13353.4     | 11986.5   | 10642.1   | 9320.0    | 8020.0     |
|                     | 8.68E-16  | 2.03E-17  | 1.42E-15  | 8.40E-16   | 9.92E-13                          | 6.28E-12  | 9.95E-09    | 5.03E-08  | 2.09E-05  | 1.12E-04  | 3.51E-02   |
|                     | 1.2782  | 1.4596  | 1.3200  | 1.2259   | 2.0684                            | -1.3137   | 1.5307      | 3.1014    | 1.4752    | 2.8062    | 1.7533     |
|                     | 2.04E-01  | 1.48E-01  | 1.91E-01  | 2.21E-01   | 2.90E-02                          | 5.13E-03  | 1.28E-01    | 1.63E-04  | 1.43E-01  | 1.28E-03  | 7.50E-02   |
|                     | 7.82E-10  | ( 7.78E-12)( 7.23E-10)( 4.51E-10)( 7.12E-09)( 1.07E-09)   | ( 7.84E-04)( 4.64E-09)( 1.05E+00)( 3.03E-04)( 2.06E+02) |  |                                   |           |             |           |           |           |            |
|                     | 7.84E-10*   | 1.00E-11*   | 6.49E-10*   | 2.64E-12*  | 1.04E-07*                         | 3.26E-05* | 2.88E-04*   | 2.02E-02* | 5.85E-01* | 6.24E+00* | 1.66E+02   |
| 15                  | .4288   | .4584   | .4918   | .5298  | .5734                             | .6239     | .6831       | .7535     | .8384     | .9430     | 1.0747     |
|                     | 23323.6   | 21817.3   | 20334.9   | 18876.0  | 17440.4                           | 16028.0   | 14638.4     | 13271.5   | 11927.1   | 10605.0   | 9305.0     |
|                     | 9.57E-17  | 9.50E-17  | 1.04E-15  | 2.66E-15   | 1.69E-14                          | 2.62E-12  | 5.24E-11    | 2.25E-08  | 3.16E-08  | 3.59E-05  | 7.91E-05   |
|                     | 1.2719  | 1.1722  | 1.1845  | 1.3548   | 1.4690                            | 2.2611    | -0.0113     | 1.6098    | 4.3896    | 1.5358    | 3.2694     |
|                     | 2.06E-01  | 2.37E-01  | 2.34E-01  | 1.80E-01   | 1.45E-01                          | 1.45E-02  | 2.25E-01    | 1.07E-01  | 2.33E-08  | 1.26E-01  | 9.55E-05   |
|                     | 1.04E-10  | 1.13E-10  | 9.70E-10  | ( 1.17E-09)( 3.83E-09)( 4.59E-09)( 1.69E-05)( 1.22E-03)( 5.87E-17)( 1.39E+00)( 1.18E-06) |                                   |           |             |           |           |           |            |
|                     | 1.05E-10*   | 1.10E-10*   | 9.00E-10*   | 1.04E-09*  | 6.38E-11*                         | 6.19E-07* | 8.86E-05*   | 3.38E-04* | 4.56E-02* | 7.42E-01* | 1.07E+01*  |

Table 7. Radiative transition parameters for  $\text{N}_2 \text{ } a^1\text{II}_g - a'^1\Sigma_u^-$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \setminus v''$ | 11        | 12        | 13         | 14          | 15         | 16         | 17         | 18          | 19         | 20         | 21       |
|--------------------|-----------|-----------|------------|-------------|------------|------------|------------|-------------|------------|------------|----------|
| 8                  | -6.5401   | -3.5902   | -2.4875    | -1.9108     | -1.5564    | -1.3165    | -1.1434    | -1.0127     | -.9105     | -.8285     | -.7612   |
|                    | -1529.0   | -2785.3   | -4020.0    | -5233.3     | -6425.3    | -7596.1    | -8745.9    | -9874.9     | -10983.0   | -12070.6   | -13137.6 |
| 4.67E-02           | 7.82E-02  | 7.38E-02  | 5.27E-02   | 3.20E-02    | 1.75E-02   | 8.94E-03   | 4.35E-03   | 2.05E-03    | 9.44E-04   | 4.29E-04   |          |
| 1.1837             | 1.1417    | 1.1089    | 1.0807     | 1.0557      | 1.0331     | 1.0124     | .9934      | .9759       | .9596      | .9444      |          |
| 2.34E-01           | 2.47E-01  | 2.57E-01  | 2.65E-01   | 2.72E-01    | 2.79E-01   | 2.85E-01   | 2.90E-01   | 2.94E-01    | 2.98E-01   | 3.02E-01   |          |
| -3.70E+01          | -4.17E+02 | -1.28E+03 | -2.15E+03  | -2.56E+03   | -2.42E+03  | -1.96E+03  | -1.42E+03  | -9.51E+02   | -5.98E+02  | -3.59E+02  |          |
| -3.67E+01          | -4.16E+02 | -1.28E+03 | -2.16E+03  | -2.57E+03   | -2.43E+03  | -1.98E+03* | -1.44E+03* | -9.61E+02*  | -6.05E+02* | -3.64E+02* |          |
| 9                  | -120.3022 | -7.4659   | -3.8848    | -2.6403     | -2.0083    | -1.6260    | -1.3699    | -1.1864     | -1.0485    | -0.9412    | -.8553   |
|                    | -83.1     | -1339.4   | -2574.1    | -3787.4     | -4979.4    | -6150.2    | -7300.0    | -8429.0     | -9537.1    | -10624.7   | -11691.7 |
| 5.58E-04           | 2.57E-02  | 6.31E-02  | 7.12E-02   | 5.76E-02    | 3.86E-02   | 2.29E-02   | 1.26E-02   | 6.54E-03    | 3.27E-03   | 1.59E-03   |          |
| .9748              | 1.1981    | 1.1499    | 1.1158     | 1.0871      | 1.0618     | 1.0301     | 1.0183     | .9993       | .9817      | .9653      |          |
| 2.94E-01           | 2.29E-01  | 2.44E-01  | 2.55E-01   | 2.63E-01    | 2.71E-01   | 2.77E-01   | 2.83E-01   | 2.88E-01    | 2.93E-01   | 2.97E-01   |          |
| -1.13E-04          | -1.32E+01 | -2.60E+02 | -1.02E+03  | -2.00E+03   | -2.67E+03  | -2.78E+03  | -2.45E+03  | -1.91E+03   | -1.36E+03  | -9.10E+02  |          |
| -1.21E-04*         | -1.30E+01 | -2.59E+02 | -1.02E+03  | -2.00E+03   | -2.67E+03  | -2.79E+03  | -2.46E+03  | -1.92E+03*  | -1.38E+03* | -9.20E+02* |          |
| 10                 | 7.4870    | 126.0224  | -8.6554    | -4.2219     | -2.8085    | -2.1135    | -1.7003    | -1.4265     | -1.2318    | -1.0863    | -.9734   |
| 1355.7             | 79.4      | -1155.4   | -2368.6    | -3560.6     | -4731.4    | -5881.2    | -7010.2    | -8118.4     | -9205.9    | -10272.9   |          |
| 7.94E-02           | 7.09E-03  | 1.08E-02  | 4.66E-02   | 6.45E-02    | 5.93E-02   | 4.38E-02   | 2.83E-02   | 1.67E-02    | 9.25E-03   | 4.90E-03   |          |
| 1.2432             | 1.1493    | 1.2211    | 1.1591     | 1.1230      | 1.0937     | 1.0681     | 1.0451     | 1.0242      | 1.0051     | .9875      |          |
| 2.15E-01           | 2.45E-01  | 2.22E-01  | 2.42E-01   | 2.53E-01    | 2.61E-01   | 2.69E-01   | 2.76E-01   | 2.81E-01    | 2.86E-01   | 2.91E-01   |          |
| 1.77E+01           | 4.29E-04  | -3.33E+00 | -1.46E+02  | -7.52E+02   | -1.74E+03  | -2.61E+03  | -3.00E+03  | -2.86E+03   | -2.40E+03  | -1.83E+03  |          |
| 1.77E+01           | 4.33E-04* | -3.28E+00 | -1.45E+02  | -7.50E+02   | -1.74E+03  | -2.62E+03  | -3.01E+03  | -2.88E+03   | -2.42E+03* | -1.84E+03* |          |
| 11                 | 3.6665    | 6.7976    | 42.2994    | -10.2369    | -4.6108    | -2.9943    | -2.2274    | -1.7799     | -1.4866    | -1.2797    | -1.1260  |
| 2727.4             | 1471.1    | 236.4     | -976.9     | -2168.8     | -3339.7    | -4489.5    | -5618.4    | -6726.6     | -7814.1    | -8881.1    |          |
| 6.89E-02           | 8.71E-02  | 1.81E-02  | 2.42E-03   | 3.10E-02    | 5.48E-02   | 5.79E-02   | 4.73E-02   | 3.31E-02    | 2.10E-02   | 1.24E-02   |          |
| 1.3323             | 1.2527    | 1.1807    | 1.2801     | 1.1700      | 1.1307     | 1.1004     | 1.0743     | 1.0512      | 1.0302     | 1.0110     |          |
| 1.87E-01           | 2.12E-01  | 2.35E-01  | 2.03E-01   | 2.38E-01    | 2.50E-01   | 2.59E-01   | 2.67E-01   | 2.74E-01    | 2.80E-01   | 2.85E-01   |          |
| 9.8/E+01           | 2.52E+01  | 2.6/E-02  | -3.78E-01  | -7.27E+01   | -5.18E+02  | -1.43E+03  | -2.43E+03  | -3.06E+03   | -3.17E+03  | -2.85E+03  |          |
| 9.88E+01           | 2.51E+01  | 2.68E-02  | -3.66E-01* | -7.20E+01   | -5.16E+02  | -1.43E+03  | -2.43E+03  | -3.07E+03   | -3.18E+03  | -2.87E+03  |          |
| 12                 | 2.4436    | 3.5261    | 6.2450     | 25.7719     | -12.4385   | -5.0638    | -3.2004    | -2.3510     | -1.8651    | -1.5506    | -1.3304  |
| 4092.3             | 2836.0    | 1601.3    | 388.0      | -804.0      | -1974.8    | -3124.6    | -4253.5    | -5361.7     | -6449.3    | -7516.3    |          |
| 2.62E-02           | 4.58E-02  | 8.77E-02  | 3.04E-02   | 3.37E-06    | 1.80E-02   | 4.36E-02   | 5.36E-02   | 4.86E-02    | 3.70E-02   | 2.51E-02   |          |
| 1.2687             | 1.3492    | 1.2618    | 1.1970     | -1.4890     | 1.1840     | 1.1389     | 1.1073     | 1.0807      | 1.0573     | 1.0362     |          |
| 2.07E-01           | 1.81E-01  | 2.09E-01  | 2.30E-01   | 2.29E-03    | 2.34E-01   | 2.48E-01   | 2.57E-01   | 2.65E-01    | 2.72E-01   | 2.78E-01   |          |
| 1.56E+02           | 6.96E+01  | 3.19E+01  | 1.90E-01   | (-3.72E-08) | -3.06E+01  | -3.31E+02  | -1.11E+03  | -2.14E+03   | -2.97E+03  | -3.33E+03  |          |
| 1.47E+02           | 6.98E+01  | 3.18E+01  | 1.90E-01   | -9.55E-03*  | -3.02E+01  | -3.29E+02  | -1.11E+03  | -2.14E+03   | -2.98E+03  | -3.35E+03  |          |
| 13                 | 1.8415    | 2.3957    | 3.4021     | 5.7933      | 18.7209    | -15.7068   | -5.5976    | -3.4300     | -2.4853    | -1.9565    | -1.6186  |
| 5430.4             | 4174.1    | 2939.4    | 1726.1     | 534.2       | -636.7     | -1786.5    | -2915.4    | -4023.6     | -5111.1    | -6178.1    |          |
| 2.41E-01           | 4.15E-02  | 2.72E-02  | 8.26E-02   | 4.17E-02    | 2.28E-03   | 8.36E-03   | 3.23E-02   | 4.72E-02    | 4.78E-02   | 3.95E-02   |          |
| 1.5047             | 1.2949    | 1.3720    | 1.2709     | 1.2088      | 1.0903     | 1.2054     | 1.1481     | 1.1144      | 1.0872     | 1.0635     |          |
| 1.35E-01           | 1.99E-01  | 1.74E-01  | 2.06E-01   | 2.26E-01    | 2.62E-01   | 2.27E-01   | 2.45E-01   | 2.55E-01    | 2.63E-01   | 2.70E-01   |          |
| 1.43E+03           | 2.41E+02  | 4.26E+01  | 3.66E+01   | 6.57E-01    | -1.64E-01  | -9.95E+00  | -1.94E+02  | -8.12E+02   | -1.79E+03  | -2.76E+03  |          |
| 1.48E+03           | 2.29E+02  | 4.28E+01  | 3.65E+01   | 6.56E-01    | -1.69E-01* | -9.77E+00* | -1.93E+02  | -8.09E+02   | -1.79E+03  | -2.76E+03  |          |
| 14                 | 1.4833    | 1.8230    | 2.3524     | 3.2920      | 5.4181     | 14.8185    | -21.0533   | -6.2347     | -3.6872    | -2.6318    | -2.0548  |
| 6741.9             | 5485.6    | 4250.9    | 3037.6     | 1845.7      | 674.8      | -475.0     | -1603.9    | -2712.1     | -3799.6    | -4866.6    |          |
| 3.08E-01           | 2.15E-01  | 5.58E-02  | 1.38E-02   | 7.36E-02    | 5.04E-02   | 7.70E-03   | 2.50E-03   | 2.18E-02    | 3.94E-02   | 4.50E-02   |          |
| 1.5851             | 1.5220    | 1.3113    | 1.4070     | 1.2802      | 1.2185     | 1.1436     | 1.2512     | 1.1588      | 1.1220     | 1.0939     |          |
| 1.13E-01           | 1.30E-01  | 1.93E-01  | 1.64E-01   | 2.03E-01    | 2.23E-01   | 2.46E-01   | 2.12E-01   | 2.42E-01    | 2.53E-01   | 2.61E-01   |          |
| 2.46E+03           | 1.22E+03  | 3.25E+02  | 2.10E+01   | 3.87E+01    | 1.56E+00   | -2.03E-01  | -1.88E+00  | -1.03E+02   | -5.61E+02  | -1.43E+03  |          |
| 2.46E+03           | 1.28E+03  | 3.10E+02  | 2.12E+01   | 3.85E+01    | 1.55E+00   | -2.05E-01* | -1.82E+00* | -1.02E+02   | -5.58E+02  | -1.43E+03  |          |
| 15                 | 1.2458    | 1.4770    | 1.8064     | 2.3134      | 3.1942     | 5.1024     | 12.3451    | -31.3580    | -7.0073    | -3.9767    | -2.7920  |
| 8026.9             | 6770.6    | 5535.9    | 4322.7     | 3130.7      | 1959.9     | 810.0      | -318.9     | -1427.1     | -2514.6    | -3581.6    |          |
| 4.03E-02           | 3.32E-01  | 1.91E-01  | 6.79E-02   | 5.28E-03    | 6.23E-02   | 5.58E-02   | 1.47E-02   | 1.17E-04    | 1.31E-02   | 3.11E-02   |          |
| 1.7725             | 1.5974    | 1.5410    | 1.3230     | 1.4743      | 1.2900     | 1.2273     | 1.1655     | 1.5746      | 1.1724     | 1.1303     |          |
| 7.12E-02           | 1.10E-01  | 1.25E-01  | 1.90E-01   | 1.44E-01    | 2.00E-01   | 2.20E-01   | 2.40E-01   | 1.16E-01    | 2.37E-01   | 2.50E-01   |          |
| ( 2.14E+02)        | 2.54E+03  | 1.02E+03  | 4.00E+02   | 6.77E+00    | 3.81E+01   | 2.91E+00   | -1.11E-01  | (-1.85E-02) | -4.75E+01  | -3.63E+02  |          |
| 1.68E+02           | 2.55E+03  | 1.09E+03  | 3.82E+02   | 6.87E+00*   | 3.79E+01   | 2.90E+00   | -1.12E-01  | -1.23E-02*  | -4.68E+01  | -3.60E+02  |          |

Table 7. Radiative transition parameters for  $N_2 a^1\Pi_g - a' ^1\Sigma_u^-$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued.

| $V' \backslash V''$ | 0         | 1         | 2         | 3           | 4           | 5           | 6           | 7           | 8           | 9           | 10          |
|---------------------|-----------|-----------|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 16                  | .4068     | .4333     | .4631     | .4967       | .5348       | .5785       | .6290       | .6882       | .7584       | .8429       | .9466       |
|                     | 24582.3   | 23076.1   | 21593.6   | 20134.7     | 18699.1     | 17286.7     | 15897.1     | 14530.2     | 13185.8     | 11863.7     | 10563.7     |
|                     | 2.62E-16  | 2.89E-16  | 1.18E-16  | 7.78E-16    | 5.14E-15    | 8.51E-14    | 5.36E-12    | 2.59E-10    | 4.57E-08    | 3.22E-09    | 5.77E-05    |
|                     | 1.2692    | 1.2151    | .9797     | 1.0836      | 1.4165      | 1.6464      | 2.5477      | .5253       | 1.6911      | 13.2760     | 1.5937      |
|                     | 2.07E-01  | 2.24E-01  | 2.93E-01  | 2.64E-01    | 1.61E-01    | 9.82E-02    | 4.41E-03    | 3.44E-01    | 8.80E-02    | 0.00E+00    | 1.11E-01    |
|                     | 3.37E-10  | 3.61E-10  | 2.07E-10  | ( 8.99E-10) | 1.76E-09    | ( 8.60E-09) | ( 8.49E-10) | 1.90E-04    | ( 1.64E-03) | ( 0.00E+00) | ( 1.70E+00) |
|                     | 3.37E-10* | 3.58E-10* | 2.02E-10* | 7.54E-10*   | 1.68E-09*   | 7.12E-10*   | 2.83E-06*   | 2.09E-04*   | 2.57E-04*   | 9.29E-02*   | 8.51E-01*   |
| 17                  | .3874     | .4114     | .4381     | .4680       | .5017       | .5400       | .5838       | .6344       | .6936       | .7636       | .8477       |
|                     | 25814.8   | 24308.6   | 22826.1   | 21367.2     | 19931.7     | 18519.2     | 17129.6     | 15762.7     | 14418.3     | 13096.2     | 11796.2     |
|                     | 7.23E-16  | 1.60E-16  | 4.84E-17  | 1.86E-17    | 3.65E-15    | 1.22E-14    | 3.80E-13    | 8.58E-12    | 9.72E-10    | 8.35E-08    | 2.80E-08    |
|                     | 1.2646    | 1.2050    | 1.6131    | -.0693      | 1.1383      | 1.4180      | 1.7754      | 2.9954      | .8326       | 1.7781      | -3.4871     |
|                     | 2.08E-01  | 2.27E-01  | 1.06E-01  | 2.07E-01    | 2.48E-01    | 1.60E-01    | 7.06E-02    | 4.71E-04    | 3.25E-01    | 7.01E-02    | 1.57E-09    |
|                     | 1.09E-09  | 2.40E-10  | 1.32E-11  | ( 1.57E-11) | ( 3.60E-09) | ( 4.02E-09) | ( 1.93E-08) | ( 1.51E-11) | ( 6.24E-04) | ( 1.87E-03) | ( 2.30E-19) |
|                     | 1.09E-09* | 2.39E-10* | 1.27E-11* | 1.19E-10*   | 3.00E-09*   | 4.70E-09*   | 1.22E-08*   | 1.03E-05*   | 4.35E-04*   | 5.37E-05*   | 1.73E-01*   |
| 18                  | .3701     | .3919     | .4161     | .4430       | .4731       | .5070       | .5454       | .5893       | .6400       | .6992       | .7691       |
|                     | 27021.4   | 25515.1   | 24032.7   | 22573.8     | 21138.2     | 19725.8     | 18336.2     | 16969.3     | 15624.9     | 14302.8     | 13002.8     |
|                     | 2.83E-16  | 3.27E-18  | 1.07E-16  | 2.31E-18    | 9.99E-16    | 1.07E-14    | 1.03E-14    | 1.41E-12    | 8.93E-12    | 3.02E-09    | 1.38E-07    |
|                     | 1.2560    | 1.0007    | 1.3781    | 3.7180      | .9330       | 1.1628      | 1.4552      | 1.8799      | 3.9652      | 1.0398      | 1.8762      |
|                     | 2.11E-01  | 2.88E-01  | 1.72E-01  | 4.83E-06    | 3.05E-01    | 2.40E-01    | 1.49E-01    | 5.26E-02    | 7.64E-07    | 2.77E-01    | 5.32E-02    |
|                     | 5.04E-10  | 9.11E-12  | 8.97E-11  | ( 1.25E-21) | 1.77E-09    | ( 9.63E-09) | ( 2.87E-09) | ( 3.86E-08) | ( 4.03E-17) | ( 1.37E-03) | ( 1.73E-03) |
|                     | 5.04E-10* | 9.16E-12* | 9.21E-11* | 1.32E-11*   | 1.65E-09*   | 7.95E-09*   | 5.71E-09*   | 8.53E-08*   | 3.18E-05*   | 8.03E-04*   | 1.16E-04*   |
| 19                  | .3546     | .3746     | .3966     | .4210       | .4480       | .4783       | .5124       | .5510       | .5950       | .6458       | .7050       |
|                     | 28202.1   | 26695.9   | 25213.4   | 23754.5     | 22318.9     | 20906.5     | 19516.9     | 18150.0     | 16805.6     | 15483.5     | 14183.5     |
|                     | 1.33E-17  | 5.73E-17  | 6.40E-18  | 2.02E-17    | 2.47E-16    | 2.42E-15    | 1.91E-14    | 7.07E-16    | 4.19E-12    | 3.10E-12    | 8.08E-09    |
|                     | 1.3176    | 1.2702    | 1.2304    | .9280       | .8345       | .9305       | 1.2053      | 1.5658      | 1.9958      | 8.1076      | 1.1962      |
|                     | 1.91E-01  | 2.06E-01  | 2.19E-01  | 3.06E-01    | 3.25E-01    | 3.05E-01    | 2.27E-01    | 1.18E-01    | 3.68E-02    | 2.45E-29    | 2.30E-01    |
|                     | 2.21E-11  | 9.41E-11  | 9.98E-12  | 5.12E-11    | 5.87E-10    | ( 4.17E-09) | ( 1.48E-08) | ( 1.20E-10) | ( 5.47E-08) | ( 0.00E+00) | ( 2.47E-03) |
|                     | 2.22E-11* | 9.46E-11* | 1.06E-11* | 4.98E-11*   | 6.01E-10*   | 3.74E-09*   | 1.17E-08*   | 4.97E-09*   | 4.62E-07*   | 8.61E-05*   | 1.31E-03*   |
| 20                  | .3406     | .3591     | .3792     | .4015       | .4260       | .4533       | .4837       | .5180       | .5568       | .6010       | .6519       |
|                     | 29357.2   | 27851.0   | 26368.5   | 24909.6     | 23474.0     | 22061.6     | 20672.0     | 19305.1     | 17960.7     | 16638.6     | 15338.6     |
|                     | 3.77E-16  | 1.16E-16  | 3.45E-17  | 9.85E-17    | 4.87E-17    | 2.39E-16    | 4.67E-15    | 3.14E-14    | 3.60E-14    | 1.07E-11    | 3.60E-12    |
|                     | 1.2695    | 1.2324    | 1.3889    | 1.2556      | .8717       | .6258       | .9750       | 1.2939      | 1.5092      | 2.1233      | -7.6198     |
|                     | 2.07E-01  | 2.18E-01  | 1.69E-01  | 2.11E-01    | 3.18E-01    | 3.46E-01    | 2.94E-01    | 1.99E-01    | 1.34E-01    | 2.40E-02    | 6.23E-35    |
|                     | 8.26E-10  | 2.42E-10  | 3.66E-11  | 1.37E-10    | 1.29E-10    | ( 6.21E-10) | ( 7.24E-09) | ( 1.81E-08) | ( 7.55E-09) | ( 5.73E-08) | ( 0.00E+00) |
|                     | 8.26E-10* | 2.42E-10* | 3.58E-11* | 1.33E-10*   | 1.27E-10*   | 7.44E-10*   | 5.94E-09*   | 1.41E-08*   | 2.21E-09*   | 1.94E-06*   | 2.07E-04*   |
| 21                  | .3280     | .3451     | .3637     | .3840       | .4064       | .4312       | .4587       | .4894       | .5238       | .5628       | .6072       |
|                     | 30486.8   | 28980.6   | 27498.1   | 26039.2     | 24603.7     | 23191.2     | 21801.6     | 20634.7     | 19090.3     | 17768.2     | 16468.2     |
|                     | 4.62E-16  | 6.24E-17  | 5.56E-17  | 5.69E-17    | 2.17E-18    | 9.20E-18    | 3.51E-16    | 7.85E-15    | 2.74E-14    | 4.66E-13    | 2.29E-11    |
|                     | 1.2609    | 1.2021    | 1.3469    | 1.3093      | 1.5010      | 2.2595      | .6710       | 1.0745      | 1.4712      | 1.5530      | 2.2826      |
|                     | 2.09E-01  | 2.28E-01  | 1.82E-01  | 1.94E-01    | 1.36E-01    | 1.46E-02    | 3.44E-01    | 2.67E-01    | 1.45E-01    | 1.22E-01    | 1.33E-02    |
|                     | 1.16E-09  | 1.60E-10  | 7.78E-11  | 7.66E-11    | ( 1.21E-12) | ( 4.94E-14) | 8.71E-10    | ( 9.69E-09) | ( 8.06E-09) | ( 7.86E-08) | ( 3.69E-08) |
|                     | 1.16E-09* | 1.60E-10* | 7.72E-11* | 7.47E-11*   | 2.03E-12*   | 2.89E-13*   | 8.80E-10*   | 6.89E-09*   | 5.93E-09*   | 1.97E-10*   | 6.90E-06*   |

Table 7. Radiative transition parameters for  $N_2$   $a^1\Pi_g - a'^1\Sigma_u^-$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . – Continued

| $V' \setminus V''$  | 11          | 12          | 13          | 14          | 15          | 16          | 17           | 18           | 19           | 20         | 21       |
|---|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|------------|----------|
| 16  | 1.0769      | 1.2454      | 1.4718      | 1.7917      | 2.2782      | 3.1070      | 4.8338       | 10.6405      | -59.3916     | -7.9623    | -4.3049  |
|   | 9285.6      | 8029.3      | 6794.6      | 5581.4      | 4389.4      | 3218.6      | 2068.7       | 939.8        | -168.4       | -1255.9    | -2322.9  |
|   | 3.70E-05    | 4.50E-02    | 3.54E-01    | 1.70E-01    | 7.71E-02    | 9.90E-04    | 5.03E-02     | 5.80E-02     | 2.20E-02     | 6.31E-04   | 6.56E-03 |
|   | 4.3673      | 1.7929      | 1.6101      | 1.5620      | 1.3316      | 1.6900      | 1.3006       | 1.2356       | 1.1795       | 1.0017     | 1.1924   |
|   | 2.82E-08    | 6.74E-02    | 1.07E-01    | 1.19E-01    | 1.87E-01    | 8.82E-02    | 1.97E-01     | 2.17E-01     | 2.35E-01     | 2.87E-01   | 2.31E-01 |
| ( 4.79E-14)( 2.14E+02)  | ( 2.58E+03) | ( 8.51E+02) | ( 4.62E+02) | ( 5.21E-01) | ( 3.50E+01) | ( 4.61E+00) | ( -2.36E-02) | ( -4.18E-01) | ( -1.78E+01) |            |          |
| 1.71E+01*   | 1.62E+02    | 2.60E+03    | 9.15E+02    | 4.41E+02    | 4.46E-01*   | 3.48E+01    | 4.59E+00     | 2.36E-02     | 4.48E-01*    | -1.74E+01* |          |
| 17  | .9507       | 1.0797      | 1.2458      | 1.4676      | 1.7787      | 2.2466      | 3.0291       | 4.6033       | 9.3970       | -427.9173  | -9.1712  |
|   | 10518.2     | 9261.9      | 8027.2      | 6813.9      | 5621.9      | 4451.1      | 3301.3       | 2172.4       | 1064.2       | -23.4      | -1090.4  |
|   | 8.71E-05    | 4.25E-06    | 4.90E-02    | 3.75E-01    | 1.52E-01    | 8.33E-02    | 3.17E-05     | 3.88E-02     | 5.71E-02     | 2.86E-02   | 3.27E-03 |
|   | 1.6507      | 10.6530     | 1.8148      | 1.6232      | 1.5849      | 1.3380      | -7.7378      | 1.3124       | 1.2436       | 1.1902     | 1.1054   |
|   | 9.72E-02    | 0.00E+00    | 6.34E-02    | 1.04E-01    | 1.13E-01    | 1.85E-01    | 4.42E-02     | 1.93E-01     | 2.15E-01     | 2.32E-01   | 2.58E-01 |
| ( 1.94E+00)( 0.00E+00)( 2.06E+02)   | ( 2.59E+03) | ( 7.01E+02) | ( 5.09E+02) | ( 4.51E-03) | ( 3.00E+01) | ( 6.44E+00) | ( -7.96E-05) | ( -1.14E+00) |              |            |          |
| 8.70E-01*   | 2.58E+01*   | 1.50E+02    | 2.62E+03    | 7.66E+02    | 4.85E+02    | 1.44E+00*   | 2.99E+01     | 6.41E+00     | 7.96E-05     | -1.17E+00* |          |
| 18  | .8529       | .9553       | 1.0830      | 1.2468      | 1.4445      | 1.7675      | 2.2184       | 2.9595       | 4.4039       | 8.4518     | 86.0763  |
|   | 11724.7     | 10468.4     | 9233.7      | 8020.5      | 6828.5      | 5657.7      | 4507.8       | 3378.9       | 2270.7       | 1183.2     | 116.2    |
|   | 2.77E-07    | 1.24E-04    | 1.06E-05    | 5.21E-02    | 3.94E-01    | 1.37E-01    | 8.67E-02     | 1.48E-03     | 2.85E-02     | 5.40E-02   | 3.39E-02 |
|   | -3.929      | 1.7083      | -4.6256     | 1.8386      | 1.6368      | 1.6098      | 1.3425       | 1.0305       | 1.3261       | 1.2515     | 1.1993   |
|   | 1.11E-01    | 8.43E-02    | 7.96E-15    | 5.93E-02    | 1.01E-01    | 1.07E-01    | 1.84E-01     | 2.80E-01     | 1.89E-01     | 2.12E-01   | 2.29E-01 |
| ( 1.12E-02)( 2.05E+00)( 1.07E-27)( 1.91E+02)                                  | ( 2.57E+03) | ( 5.75E-02) | ( 5.42E+02) | ( 9.02E+00) | ( 2.41E+01) | ( 8.17E+00) | ( 5.65E-03)  |              |              |            |          |
| 2.99E-01*   | 7.66E-01*   | 3.70E+01*   | 1.31E+02    | 2.62E+03    | 6.40E+02    | 5.14E+02    | 8.67E+00*    | 2.40E+01     | 8.13E+00     | 5.64E-03   |          |
| 19  | .7749       | .8584       | .9602       | 1.0868      | 1.2486      | 1.4623      | 1.7579       | 2.1932       | 2.8973       | 4.2303     | 7.7107   |
|   | 12905.5     | 11649.2     | 10414.5     | 9201.2      | 8009.2      | 6858.4      | 5688.6       | 4559.6       | 3451.4       | 2363.9     | 1296.9   |
|   | 2.04E-07    | 1.11E-06    | 1.67E-04    | 9.86E-05    | 5.41E-02    | 4.12E-01    | 1.25E-01     | 8.75E-02     | 4.48E-03     | 1.98E-02   | 4.92E-02 |
|   | 1.9938      | .4202       | 1.7684      | -.5650      | 1.8646      | 1.6507      | 1.6367       | 1.3451       | 1.1657       | 1.3428     | 1.2594   |
|   | 3.71E-02    | 3.33E-01    | 7.20E-02    | 7.26E-02    | 5.50E-02    | 9.72E-02    | 1.01E-01     | 1.83E-01     | 2.39E-01     | 1.83E-01   | 2.10E-01 |
| ( 1.22E-03)( 3.95E-01)( 1.08E+00)( 8.21E-01)( 1.70E+02)                       | ( 2.52E+03) | ( 4.72E+02) | ( 5.61E-02) | ( 2.14E+01) | ( 1.78E+01) | ( 9.57E+00) |              |              |              |            |          |
| 1.75E-03*   | 4.79E-01*   | 5.38E+01*   | 5.07E+01*   | 1.07E+02    | 2.59E+03    | 5.35E+02    | 5.29E+02     | 2.05E+01*    | 1.78E+01     | 9.52E+00   |          |
| 20  | .7112       | .7810       | .8643       | .9656       | 1.0912      | 1.2510      | 1.4612       | 1.7499       | 2.1708       | 2.8417     | 4.0783   |
|   | 14060.5     | 12804.2     | 11569.5     | 10356.3     | 9164.3      | 7993.5      | 6843.7       | 5714.7       | 4606.5       | 3519.0     | 2452.0   |
|   | 1.92E-08    | 2.68E-07    | 3.16E-06    | 2.13E-04    | 3.24E-04    | 5.48E-02    | 4.29E-01     | 1.17E-01     | 8.62E-02     | 8.35E-03   | 1.29E-02 |
|   | 1.3245      | 2.1460      | .8075       | 1.8333      | .3625       | 1.8934      | 1.6651       | 1.3455       | 1.2189       | 1.3646     |          |
|   | 1.89E-01    | 2.21E-02    | 3.29E-01    | 6.02E-02    | 3.24E-01    | 5.05E-02    | 9.39E-02     | 9.39E-02     | 1.83E-01     | 2.23E-01   | 1.77E-01 |
| ( 3.88E-03)( 5.60E-04)( 1.07E+00)( 1.73E+00)( 5.31E+01)( 1.45E+02)            | ( 2.46E+03) | ( 3.88E+02) | ( 5.69E+02) | ( 3.65E+01) | ( 1.20E+01) | ( 1.20E+01) |              |              |              |            |          |
| 1.87E-03*   | 8.01E-03*   | 7.17E-01*   | 2.42E-01*   | 6.65E+01*   | 8.10E+01    | 2.54E+03    | 4.49E+02     | 5.33E+02     | 3.54E+01*    | 1.20E+01   |          |
| 21  | .6583       | .7177       | .7875       | .8706       | .9714       | 1.0961      | 1.2542       | 1.4611       | 1.7433       | 2.1512     | 2.7920   |
|   | 15190.2     | 13933.9     | 12699.2     | 11485.9     | 10293.9     | 9123.1      | 7973.3       | 6844.3       | 5736.2       | 4648.6     | 3581.6   |
|   | 9.40E-11    | 4.12E-08    | 3.02E-07    | 7.42E-06    | 2.55E-04    | 7.54E-04    | 5.40E-02     | 4.46E-01     | 1.11E-01     | 8.30E-02   | 1.26E-02 |
|   | -1.0060     | 1.4376      | 2.3649      | 1.0422      | 1.9062      | .7826       | 1.9259       | 1.6800       | 1.6947       | 1.3431     | 1.2505   |
|   | 1.78E-02    | 1.54E-01    | 9.62E-03    | 2.76E-01    | 4.86E-02    | 3.33E-01    | 4.58E-02     | 9.05E-02     | 8.72E-02     | 1.83E-01   | 2.13E-01 |
| ( 2.12E-07)( 5.39E-03)( 1.16E-04)( 1.74E+00)( 1.33E+00)( 1.29E+02)( 1.16E+02) | ( 2.37E+03) | ( 3.23E+02) | ( 5.68E+02) | ( 5.29E+01) | ( 1.20E+01) | ( 1.20E+01) |              |              |              |            |          |
| 4.46E-04*   | 2.25E-03*   | 2.48E-02*   | 1.00E+00*   | 1.83E-02*   | 8.41E+01*   | 5.44E+01    | 2.48E+03     | 3.82E+02     | 5.26E+02     | 5.16E+01   |          |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 8. Radiative transition parameters for  $\text{N}_2 w^{-1}\Delta_u - a^{-1}\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $v'\backslash v''$ | 0   | 1   | 2  | 3   | 4  | 5   | 6  | 7   | 8   | 9  | 10  |  |
|--------------------|---|---|--|---|--|---|--|---|---|--|---|--|
| 0                  | 3.6400<br>2747.3<br>6.77E-01<br>1.2493<br>2.12E-01<br>1.28E+03<br>1.28E+03  | 9.2512<br>1080.9<br>3.87E-02<br>1.3140<br>1.94E-01<br>2.71E+01<br>2.73E+01  | -17.9347<br>-557.6<br>1.95E-03<br>1.3963<br>1.69E-01<br>-3.86E-01<br>-3.90E-01 | -4.6118<br>-2168.3<br>2.64E-05<br>1.5138<br>1.32E-01<br>-7.09E-01<br>-7.04E-01* | -2.6657<br>-3751.4<br>4.22E-10<br>1.7438<br>7.13E-02<br>(-1.44E-02)<br>(-0.00E+00) | -1.8843<br>-5306.9<br>2.84E-09<br>11.7050<br>0.00E+00<br>(-2.16E-05)<br>(-0.00E+00) | -1.4631<br>-6834.8<br>2.06E-12<br>1.5962<br>1.09E-01<br>1.05E-03<br>-1.14E-03* | -1.1997<br>-8335.3<br>3.83E-13<br>-8297<br>2.42E-02<br>2.0385<br>-9.09E-06*       | -1.0195<br>-9808.5<br>6.43E-15<br>1.3095<br>1.95E-01<br>1.4561<br>-1.10E-08*      | -8885<br>-11254.4<br>2.20E-16<br>1.3095<br>1.50E-01<br>1.4561<br>-6.41E-10*    | -7.7891<br>-12673.1<br>2.20E-16<br>1.4561<br>1.50E-01<br>1.4561<br>-8.46E-13*   |  |
| 1                  | 2.3348<br>4283.0<br>2.44E-01<br>1.1897<br>2.28E-01<br>2.02E+03<br>2.03E+03  | 3.8217<br>2616.6<br>3.98E-01<br>1.2634<br>1.91E-01<br>4.02E+02<br>3.97E+02  | 10.2240<br>978.1<br>9.56E-02<br>1.3232<br>1.66E-01<br>-1.35E+00<br>-2.76E+01   | -15.8060<br>-632.7<br>6.78E-03<br>1.4050<br>1.29E-01<br>-2.50E+00<br>-2.48E+00* | -4.5131<br>-2215.7<br>1.11E-04<br>1.5241<br>6.66E-02<br>0.00E+00<br>-3.14E-02*     | -2.6517<br>-3771.2<br>2.76E-09<br>1.7653<br>6.66E-02<br>9.49E-02<br>-6.95E-03*      | -1.8871<br>-5299.1<br>1.93E-08<br>-7.6412<br>0.0045<br>6.03E-02<br>-3.57E-05*  | -1.4707<br>-6799.6<br>3.72E-11<br>1.6464<br>.0045<br>1.15E-02<br>-1.66E-05*       | -1.2088<br>-8272.8<br>2.89E-12<br>2.2033<br>1.5287<br>1.15E-02<br>-1.83E-07*      | -1.0289<br>-9718.7<br>3.57E-14<br>2.2033<br>1.5287<br>1.28E-01<br>-7.86E-10*   | -8.8979<br>-11137.5<br>3.57E-14<br>1.5287<br>1.28E-01<br>1.28E-01<br>-7.86E-10* |  |
| 2                  | 1.7256<br>5795.0<br>6.16E-02<br>1.1419<br>2.39E-01<br>1.38E+03<br>1.40E+03  | 2.4221<br>4128.7<br>6.46E-02<br>1.1976<br>2.01E-01<br>8.16E+01<br>2.08E+03  | 4.0158<br>2490.2<br>4.14E-01<br>1.2892<br>1.80E-01<br>2.02E+01<br>7.90E+01     | 11.3714<br>879.4<br>1.58E-01<br>1.3330<br>1.63E-01<br>-2.96E+00<br>-2.99E+00    | -14.2110<br>-703.7<br>1.47E-02<br>1.4140<br>1.26E-01<br>-5.49E+00<br>-5.42E+00     | -4.4265<br>-2259.1<br>2.79E-04<br>1.5346<br>1.7886<br>-1.4596<br>-6.95E-03*         | -2.6406<br>-3787.1<br>7.91E-08<br>1.6985<br>1.4532<br>1.2185<br>-1.4791        | -1.8912<br>-5287.6<br>7.39E-08<br>1.6985<br>.4532<br>-1.0389<br>-1.4791           | -1.4791<br>-6760.7<br>3.09E-10<br>1.16E-11<br>.4532<br>-1.2185<br>-1.2185         | -1.2185<br>-8206.6<br>9.625.4<br>1.16E-11<br>2.4129<br>3.85E-03<br>-9.625.4    | -1.0389<br>-9625.4<br>1.16E-11<br>2.4129<br>3.85E-03<br>-1.0389<br>-1.0389      |  |
| 3                  | 1.3729<br>7283.8<br>1.36E-02<br>1.1014<br>2.47E-01<br>6.48E+02<br>6.60E+02  | 1.7802<br>5617.4<br>1.23E-01<br>1.1484<br>2.24E-01<br>2.49E-03<br>2.51E+03  | 2.5133<br>3978.9<br>2.39E-01<br>1.2064<br>1.60E-01<br>1.53E+03<br>(2.39E+00)   | 4.2227<br>2368.1<br>3.46E-03<br>1.4228<br>1.85E-01<br>1.26E+01<br>2.04E+00*     | 12.7379<br>785.1<br>3.77E-01<br>1.3438<br>1.60E-01<br>1.26E+01<br>-2.99E+00        | -12.9802<br>-770.4<br>2.17E-01<br>1.4232<br>1.23E-01<br>-5.17E+00<br>-5.42E+00      | -4.3510<br>-2298.3<br>2.56E-02<br>1.5454<br>1.23E-01<br>-9.54E+00<br>-9.41E+00 | -2.6324<br>-3798.8<br>5.41E-04<br>1.8142<br>5.67E-02<br>(-1.93E-01)<br>-8.10E-02* | -1.8968<br>-5272.0<br>5.50E-07<br>-1.812<br>3.06E-02<br>(-1.53E-04)<br>-6.32E-05* | -1.4886<br>-6717.9<br>2.08E-07<br>1.7536<br>6.91E-02<br>5.00E-04<br>-7.38E-05* | -1.4886<br>-8136.7<br>1.66E-09<br>.7315<br>2.52E-01<br>2.4129<br>-8136.7        | -1.2290<br>-8136.7<br>1.66E-09<br>.7315<br>2.52E-01<br>2.4129<br>-8136.7       |
| 4                  | 1.1429<br>8749.4<br>2.85E-03<br>1.0662<br>2.53E-01<br>2.47E+02<br>2.53E+02* | 1.4118<br>7083.1<br>3.84E-02<br>1.1075<br>2.36E-01<br>9.18E+02<br>1.70E+03  | 1.8367<br>5444.6<br>1.60E-01<br>1.1552<br>2.21E-01<br>9.18E+02<br>2.93E+03     | 2.6084<br>3833.8<br>8.04E-03<br>1.2166<br>2.35E-01<br>1.03E+01<br>9.06E+02      | 4.4430<br>2250.7<br>3.16E-01<br>1.1570<br>1.81E-01<br>7.07E+00<br>1.14E+01*        | 14.3828<br>695.3<br>2.69E-01<br>1.3558<br>1.81E-01<br>-7.80E+00<br>7.03E+00         | -12.0097<br>-832.7<br>2.69E-01<br>1.4328<br>1.57E-01<br>-1.44E+01<br>-7.86E+00 | -4.2860<br>-2333.2<br>3.90E-02<br>1.5565<br>1.20E-01<br>(-2.63E-01)<br>-1.42E+01  | -2.6272<br>-3806.3<br>8.89E-04<br>1.8425<br>5.14E-02<br>(-1.74E-02)<br>-8.17E-02* | -1.9040<br>-5252.2<br>2.29E-06<br>.3789<br>1.61E-01<br>5.67E-02<br>-1.9040     | -1.4990<br>-6671.0<br>4.74E-07<br>1.8139<br>5.67E-02<br>-1.4990<br>-1.4990      | -1.4990<br>-6671.0<br>4.74E-07<br>1.8139<br>5.67E-02<br>-1.4990<br>-1.4990     |
| 5                  | .9811<br>10192.3<br>5.89E-04<br>1.0352<br>2.57E-01<br>8.35E+01<br>8.59E+01* | 1.1729<br>8526.0<br>1.04E-02<br>1.0721<br>2.44E-01<br>8.31E+02<br>8.49E+02  | 1.4519<br>6887.5<br>7.60E-02<br>1.1136<br>1.2164<br>2.34E-01<br>2.77E+03       | 1.8951<br>5276.7<br>9.70E-01<br>1.1136<br>1.2295<br>2.18E-01<br>4.48E+02        | 2.7074<br>3693.6<br>9.51E-02<br>1.1624<br>1.2236<br>2.19E-01<br>3.91E+01           | 4.6769<br>2138.2<br>3.96E-02<br>1.2236<br>1.3696<br>1.77E-01<br>3.56E+00            | 16.3871<br>610.2<br>2.49E-01<br>1.3696<br>1.4427<br>1.54E-01<br>-1.07E+01      | -11.2327<br>-890.3<br>3.13E-01<br>1.4427<br>1.5679<br>1.17E-01<br>-1.94E+01       | -4.2312<br>-2363.4<br>5.43E-02<br>1.5679<br>1.8742<br>4.60E-02<br>-5.69E-02*      | -2.6252<br>-3809.3<br>1.30E-03<br>1.8742<br>.6970<br>2.46E-01<br>-5.69E-02*    | -1.9127<br>-5228.1<br>7.10E-06<br>.6970<br>2.46E-01<br>1.8139<br>-1.9127        | -1.9127<br>-5228.1<br>7.10E-06<br>.6970<br>2.46E-01<br>1.8139<br>-1.9127       |
| 6                  | .8611<br>11612.7<br>1.23E-04<br>1.0078<br>2.60E-01<br>2.64E+01<br>2.72E+01* | 1.0054<br>9946.4<br>2.65E-03<br>1.0410<br>2.51E-01<br>3.48E+02<br>3.57E+02* | 1.2037<br>8307.9<br>2.27E-02<br>1.0780<br>2.43E-01<br>1.66E+03<br>1.69E+03     | 1.4932<br>6697.1<br>9.22E-02<br>1.1199<br>2.32E+03<br>2.29E+03<br>3.35E+03      | 1.9554<br>5114.0<br>1.56E-01<br>1.1700<br>2.12E-01<br>1.80E+02<br>2.28E+03         | 2.8101<br>3558.6<br>4.36E-02<br>1.2488<br>2.12E-01<br>5.91E+01<br>7.03E+00          | 4.9246<br>2030.6<br>7.65E-02<br>1.2446<br>1.72E-01<br>1.66E+00<br>6.03E+01     | 18.8635<br>530.1<br>1.86E-01<br>1.3860<br>1.4529<br>1.51E-01<br>1.64E+00          | -10.6042<br>-943.0<br>1.07E-01<br>1.4529<br>1.5796<br>1.13E-01<br>-1.36E+01       | -4.1860<br>-2388.9<br>3.47E-01<br>1.4061<br>1.5917<br>4.03E-02<br>-2.46E+01    | -2.6263<br>-3807.7<br>1.74E-03<br>1.4061<br>1.5917<br>4.03E-02<br>-2.6263       | -2.6263<br>-3807.7<br>1.74E-03<br>1.4061<br>1.5917<br>4.03E-02<br>-2.6263      |
| 7                  | .7686<br>13010.9<br>2.62E-05<br>.9837<br>2.63E-01<br>8.07E+00<br>8.35E+00*  | .8815<br>11344.5<br>6.57E-04<br>1.0136<br>2.56E-01<br>8.31E+02<br>8.35E+02* | 1.0303<br>9706.0<br>6.91E-03<br>1.0468<br>2.50E-01<br>8.36E+02<br>8.57E+02*    | 1.2353<br>8095.2<br>3.80E-02<br>1.0839<br>2.42E-01<br>2.55E+03<br>2.60E+03      | 1.5356<br>6512.2<br>1.09E-01<br>1.1263<br>2.31E-01<br>3.57E+03<br>3.60E+03         | 2.0175<br>4956.7<br>1.29E-01<br>1.1782<br>2.31E-01<br>1.70E+03<br>1.68E+03          | 2.9165<br>3428.8<br>1.30E-02<br>1.2881<br>2.01E-01<br>4.32E+01<br>3.97E+01     | 5.1860<br>1928.3<br>1.07E-01<br>1.2576<br>2.10E-01<br>6.88E+01<br>6.95E+01        | 21.9722<br>455.1<br>1.31E-01<br>1.4061<br>1.66E-01<br>6.88E-01<br>6.78E-01        | -10.0931<br>-990.8<br>3.73E-01<br>1.4635<br>1.48E-01<br>-1.61E+01<br>-1.62E+01 | -4.1502<br>-2409.6<br>8.85E-02<br>1.5917<br>1.10E-01<br>-3.02E+01<br>-2.96E+01  | -4.1502<br>-2409.6<br>8.85E-02<br>1.5917<br>1.10E-01<br>-3.02E+01<br>-2.96E+01 |

Table 8. Radiative transition parameters for  $N_2 w^1\Delta_u - a^1\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu m$ ),  $\nu_{v'v''}$  ( $cm^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $s^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $s^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \setminus V''$ | 11          | 12          | 13          | 14          | 15          | 16          | 17          | 18          | 19          | 20          | 21       |
|--------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----------|
| 0                  | -.7110      | -.6481      | -.5964      | -.5531      | -.5164      | -.4849      | -.4575      | -.4336      | -.4125      | -.3937      | -.3770   |
|                    | -14064.9    | -15429.8    | -16767.9    | -18079.4    | -19364.4    | -20623.1    | -21855.6    | -23062.1    | -24242.8    | -25397.7    | -26526.8 |
| 1.20E-15           | 1.20E-15    | 2.65E-16    | 2.21E-17    | 1.90E-16    | 8.24E-17    | 1.97E-18    | 7.35E-17    | 7.24E-17    | 9.51E-18    | 9.96E-18    |          |
| 1.1606             | 1.1534      | 1.0886      | 1.6056      | 1.2963      | 1.2379      | 1.5063      | 1.2736      | 1.2397      | 1.1672      | 1.3105      |          |
| 2.35E-01           | 2.36E-01    | 2.49E-01    | 1.06E-01    | 1.99E-01    | 2.15E-01    | 1.35E-01    | 2.05E-01    | 2.15E-01    | 2.33E-01    | 1.95E-01    |          |
| (-3.72E-10)        | (-4.97E-10) | (-1.57E-10) | (-2.97E-12) | (-1.11E-10) | (-6.79E-11) | (-7.58E-13) | (-7.71E-11) | (-9.64E-11) | (-1.71E-11) | (-1.43E-11) |          |
| -2.96E-10*         | -4.65E-10*  | -1.52E-10*  | -5.17E-12*  | -1.17E-10*  | -7.11E-11*  | -6.50E-13*  | -7.64E-11*  | -9.66E-11*  | -1.78E-11*  | -1.38E-11*  |          |
| 1                  | -.7981      | -.7197      | -.6565      | -.6045      | -.5609      | -.5239      | -.4921      | -.4645      | -.4404      | -.4191      | -.4001   |
|                    | -12529.2    | -13894.1    | -15232.2    | -16543.7    | -17828.7    | -19087.4    | -20320.0    | -21526.5    | -22707.1    | -23862.0    | -24991.1 |
| 8.32E-15           | 6.39E-15    | 2.85E-15    | 7.38E-16    | 2.02E-17    | 5.15E-17    | 4.50E-17    | 2.43E-20    | 2.54E-17    | 2.64E-17    | 7.45E-19    |          |
| 1.3186             | 1.0968      | 1.0415      | .9941       | .3451       | 1.5566      | 1.3845      | 1.7536      | 1.3159      | 1.3515      | 2.0731      |          |
| 1.92E-01           | 2.48E-01    | 2.56E-01    | 2.62E-01    | 1.50E-01    | 1.20E-01    | 1.72E-01    | 6.91E-02    | 1.93E-01    | 1.82E-01    | 2.09E-02    |          |
| (-1.23E-09)        | (-2.13E-09) | (-1.34E-09) | (-4.64E-10) | (-5.26E-12) | (-1.04E-11) | (-2.27E-11) | (-2.34E-15) | (-2.25E-11) | (-2.42E-11) | (-1.02E-14) |          |
| -3.08E-10*         | -1.53E-09*  | -1.22E-09*  | -4.44E-10*  | -3.06E-11*  | -1.97E-11*  | -2.98E-11*  | -1.34E-13*  | -2.22E-11*  | -2.65E-11*  | -9.35E-14*  |          |
| 2                  | -.9077      | -.8076      | -.7289      | -.6653      | -.6129      | -.5690      | -.5317      | -.4996      | -.4718      | -.4474      | -.4259   |
|                    | -11017.2    | -12382.0    | -13720.1    | -15031.7    | -16316.7    | -17575.4    | -18807.9    | -20014.4    | -21195.0    | -22349.9    | -23479.1 |
| 2.65E-13           | 4.02E-14    | 3.29E-14    | 1.22E-14    | 3.21E-15    | 3.92E-16    | 1.84E-19    | 3.37E-17    | 4.00E-17    | 4.52E-17    | 8.51E-17    |          |
| 1.6888             | 1.3113      | 1.1059      | 1.0055      | .9294       | .7070       | -11.1370    | 1.5052      | 1.0964      | .8822       | .8671       |          |
| 8.41E-02           | 1.95E-01    | 2.46E-01    | 2.61E-01    | 2.66E-01    | 2.48E-01    | 0.00E+00    | 1.35E-01    | 2.48E-01    | 2.66E-01    | 2.65E-01    |          |
| (-5.09E-09)        | (-5.85E-09) | (-1.04E-08) | (-5.72E-09) | -1.99E-09   | (-2.66E-10) | (0.00E+00)  | (-9.99E-12) | (-4.73E-11) | (-7.23E-11) | (-1.57E-10) |          |
| -2.95E-10*         | -1.38E-09*  | -6.79E-09*  | -5.08E-09*  | -2.01E-09*  | -3.98E-10*  | -1.05E-11*  | -2.17E-11*  | -5.52E-11*  | -9.11E-11*  | -1.91E-10*  |          |
| 3                  | -1.0495     | -.9180      | -.8176      | -.7384      | -.6744      | -.6216      | -.5774      | -.5398      | -.5075      | -.4794      | -.4547   |
|                    | -9528.4     | -10893.3    | -12231.4    | -13542.9    | -14827.9    | -16086.6    | -17319.2    | -18525.7    | -19706.3    | -20861.2    | -21990.3 |
| 3.13E-11           | 1.40E-12    | 1.38E-13    | 1.34E-13    | 4.21E-14    | 9.85E-15    | 1.80E-15    | 9.08E-17    | 2.64E-16    | 1.45E-15    | 2.77E-15    |          |
| 2.7026             | 1.8185      | 1.2876      | 1.1181      | .9719       | .8602       | .7754       | .5457       | 1.1498      | 1.0746      | 1.0548      |          |
| 6.52E-04           | 5.59E-02    | 2.01E-01    | 2.44E-01    | 2.63E-01    | 2.65E-01    | 2.58E-01    | 2.11E-01    | 2.37E-01    | 2.51E-01    | 2.54E-01    |          |
| (-2.33E-11)        | (-1.15E-08) | (-2.07E-08) | (-4.00E-08) | (-1.93E-08) | (-5.84E-09) | (-1.27E-09) | (-5.20E-11) | (-2.30E-10) | -1.68E-09   | -3.87E-09   |          |
| -7.44E-06*         | -4.38E-09*  | -5.20E-09*  | -2.41E-08*  | -1.69E-08*  | -6.39E-09*  | -1.56E-09*  | -8.86E-11*  | -2.89E-10*  | -1.74E-09*  | -3.86E-09*  |          |
| 4                  | -1.2403     | -1.0607     | -.9289      | -.8280      | -.7484      | -.6839      | -.6308      | -.5862      | -.5482      | -.5156      | -.4872   |
|                    | -8062.7     | -9427.6     | -10765.7    | -12077.2    | -13362.3    | -14621.0    | -15853.5    | -17060.0    | -18240.6    | -19395.5    | -20524.6 |
| 6.67E-09           | 5.85E-11    | 5.75E-12    | 2.86E-13    | 3.97E-13    | 1.25E-13    | 2.78E-14    | 3.01E-15    | 7.74E-16    | 9.36E-15    | 2.10E-14    |          |
| .9251              | 3.1882      | 1.9389      | 1.2246      | 1.1284      | .9723       | .8672       | .7588       | 1.2849      | 1.0941      | 1.0743      |          |
| 2.66E-01           | 1.65E-05    | 3.61E-02    | 2.19E-01    | 2.42E-01    | 2.63E-01    | 2.65E-01    | 2.56E-01    | 2.02E-01    | 2.48E-01    | 2.51E-01    |          |
| (5.00E-04)         | (2.71E-14)  | (-1.90E-09) | (-4.89E-08) | (-1.12E-07) | (-5.51E-08) | -1.58E-08   | (-1.99E-09) | (-3.89E-10) | -8.52E-09   | -2.33E-08   |          |
| -6.10E-04*         | -2.97E-05*  | -1.02E-07*  | -1.26E-08*  | -6.09E-08*  | -4.53E-08*  | -1.63E-08*  | -2.29E-09*  | -6.44E-10*  | -8.92E-09*  | -2.33E-08*  |          |
| 5                  | -1.5106     | -1.2524     | -1.0726     | -.9403      | -.8390      | -.7588      | -.6939      | -.6403      | -.5953      | -.5570      | -.5241   |
|                    | -6619.8     | -7984.7     | -9322.8     | -10434.3    | -11019.4    | -13178.1    | -14410.6    | -15617.1    | -16797.7    | -17952.6    | -19081.7 |
| 9.23E-07           | 2.19E-08    | 7.01E-11    | 1.94E-11    | 3.53E-13    | 9.36E-13    | 2.81E-13    | 3.53E-14    | 1.43E-15    | 4.03E-14    | 9.79E-14    |          |
| 1.8817             | 1.0713      | 4.2019      | 2.0545      | 1.0627      | 1.1507      | .9896       | .8134       | 1.7442      | 1.1191      | 1.0722      |          |
| 4.47E-02           | 2.52E-02    | 4.63E-10    | 2.26E-02    | 2.53E-01    | 2.37E-01    | 2.62E-01    | 2.62E-01    | 7.12E-02    | 2.43E-01    | 2.52E-01    |          |
| (-1.09E-03)        | (-1.44E-03) | (-2.47E-23) | (-2.41E-08) | (-7.78E-08) | (-2.43E-07) | (-1.17E-07) | -1.88E-08   | (-6.95E-11) | -2.80E-08   | -8.73E-08   |          |
| -2.54E-04*         | -1.32E-03*  | -9.70E-05*  | -7.97E-07*  | -2.46E-08*  | -1.14E-07*  | -8.45E-08*  | -1.87E-08*  | -6.28E-10*  | -2.98E-08*  | -8.83E-08*  |          |
| 6                  | -1.9233     | -1.5234     | -1.2654     | -1.0853     | -.9525      | -.8505      | -.7698      | -.7044      | -.6503      | -.6049      | -.5662   |
|                    | -5199.5     | -6564.3     | -7902.5     | -9214.0     | -10499.0    | -11757.7    | -12990.2    | -14196.7    | -15377.3    | -16532.2    | -17661.4 |
| 1.82E-05           | 1.50E-06    | 6.17E-08    | 3.22E-11    | 5.58E-11    | 8.27E-14    | 1.51E-12    | 3.49E-13    | 5.92E-16    | 1.23E-13    | 3.65E-13    |          |
| .9056              | 1.9606      | 1.1888      | 7.9958      | 2.1710      | .0002       | 1.1879      | 1.0057      | -1.4622     | 1.1520      | 1.0717      |          |
| 2.66E-01           | 3.32E-02    | 2.28E-01    | 9.36E-42    | 1.34E-02    | 5.95E-02    | 2.28E-01    | 2.61E-01    | 8.74E-06    | 2.37E-01    | 2.52E-01    |          |
| (-3.67E-01)        | (-9.97E-04) | (-3.20E-03) | (0.00E+00)  | (-2.35E-08) | (-9.63E-10) | (-3.50E-07) | (-1.37E-07) | (-3.33E-19) | (-6.29E-08) | -2.58E-07   |          |
| -4.42E-01*         | -1.96E-03*  | -2.48E-03*  | -2.71E-04*  | -4.01E-06*  | -3.24E-08*  | -1.19E-07*  | -7.19E-08*  | -1.28E-10*  | -7.10E-08*  | -2.65E-07*  |          |
| 7                  | -2.6307     | -1.9357     | -1.5374     | -1.2795     | -1.0988     | -.9653      | -.8627      | -.7813      | -.7153      | -.6608      | -.6149   |
|                    | -3801.3     | -5166.2     | -6504.3     | -7815.8     | -9100.8     | -10359.5    | -11592.0    | -12798.6    | -13979.2    | -15134.1    | -16263.2 |
| 2.15E-03           | 4.08E-05    | 2.40E-06    | 1.53E-07    | 1.36E-11    | 1.41E-10    | 7.94E-13    | 1.27E-12    | 1.19E-13    | 2.57E-13    | 1.18E-12    |          |
| 1.9516             | 1.0555      | 2.0566      | 1.2884      | -13.7450    | 2.2879      | 2.2527      | 1.2791      | 1.1032      | 1.1641      | 1.0785      |          |
| 3.44E-02           | 2.54E-01    | 2.24E-02    | 2.01E-01    | 0.00E+00    | 7.54E-03    | 9.01E-03    | 2.04E-01    | 2.46E-01    | 2.34E-01    | 2.51E-01    |          |
| (-2.83E-01)        | (-7.37E-01) | (-6.71E-04) | (-5.99E-03) | (0.00E+00)  | (-1.81E-08) | (-2.03E-10) | (-2.71E-07) | (-3.99E-08) | (-9.86E-08) | -6.44E-07   |          |
| -6.03E-04*         | -6.91E-01*  | -7.86E-03*  | -4.07E-03*  | -6.67E-04*  | -1.53E-05*  | -1.52E-08*  | 1.61E-08*   | -1.48E-10*  | -1.44E-07*  | -6.77E-07*  |          |

Table 8. Radiative transition parameters for  $N_2 w^1\Delta_u - a^1\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu m$ ),  $\nu_{v'v''}$  ( $cm^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $s^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $s^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . - Continued

| V'V'' | 0         | 1         | 2         | 3         | 4         | 5         | 6         | 7           | 8           | 9        | 10          |
|-------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-------------|-------------|----------|-------------|
| 8     | .6951     | .7861     | .9023     | 1.0558    | 1.2677    | 1.5791    | 2.0812    | 3.0262      | 5.4606      | 25.9469  | -9.6771     |
|       | 14387.0   | 12720.7   | 11082.2   | 9471.4    | 7888.3    | 6329.9    | 4804.9    | 3304.4      | 1831.3      | 385.4    | -1033.4     |
|       | 5.82E-06  | 1.63E-04  | 1.99E-03  | 1.36E-02  | 5.40E-02  | 1.16E-01  | 9.69E-02  | 8.09E-04    | 1.28E-01    | 8.77E-02 | 3.92E-01    |
|       | .9631     | .9895     | 1.0193    | 1.0526    | 1.0900    | 1.1330    | 1.1876    | 1.5145      | 1.2679      | 1.4321   | 1.4746      |
|       | 2.64E-01  | 2.62E-01  | 2.59E-01  | 2.55E-01  | 2.49E-01  | 2.41E-01  | 2.28E-01  | 1.32E-01    | 2.07E-01    | 1.58E-01 | 1.44E-01    |
|       | 2.45E+00  | 4.66E+01  | 3.69E+02  | 1.52E+03  | 3.32E+03  | 3.45E+03  | 1.13E+03  | ( 1.03E+00) | 6.84E+01    | 2.53E-01 | -1.83E+01   |
|       | 2.53E+00* | 4.81E+01* | 3.79E+02* | 1.55E+03  | 3.37E+03  | 3.46E+03  | 1.12E+03  | 6.49E-01*   | 6.86E+01    | 2.48E-01 | -1.85E+01   |
| 9     | .6353     | .7105     | .8041     | .9237     | 1.0819    | 1.3008    | 1.6235    | 2.1464      | 3.1389      | 5.7475   | 31.1413     |
|       | 15741.5   | 14075.2   | 12436.7   | 10825.9   | 9242.8    | 7687.4    | 6159.4    | 4658.9      | 3185.8      | 1739.9   | 321.1       |
|       | 1.36E-06  | 4.11E-05  | 5.64E-04  | 4.50E-03  | 2.24E-02  | 6.81E-02  | 1.13E-01  | 6.51E-02    | 2.17E-03    | 1.38E-01 | 5.48E-02    |
|       | .9462     | .9688     | .9952     | 1.0251    | 1.0585    | 1.0961    | 1.1399    | 1.1989      | 1.0484      | 1.2769   | 1.4679      |
|       | 2.65E-01  | 2.64E-01  | 2.62E-01  | 2.58E-01  | 2.54E-01  | 2.48E-01  | 2.39E-01  | 2.25E-01    | 2.55E-01    | 2.05E-01 | 1.46E-01    |
|       | 7.53E-01  | 1.61E+01  | 1.50E+02  | 7.73E+02  | 2.31E+03  | 3.85E+03  | 3.05E+03  | 6.78E+02    | ( 9.25E+00) | 6.16E+01 | 7.89E-02    |
|       | 7.79E-01* | 1.67E+01* | 1.55E+02* | 7.94E+02* | 2.35E+03  | 3.89E+03  | 3.05E+03  | 6.60E+02    | 1.18E+01*   | 6.15E+01 | 7.75E-02    |
| 10    | .5857     | .6490     | .7262     | .8224     | .9455     | 1.1086    | 1.3347    | 1.6689      | 2.2129      | 3.2542   | 6.0453      |
|       | 17074.6   | 15408.3   | 13769.7   | 12159.0   | 10575.9   | 9020.4    | 7492.5    | 5992.0      | 4518.9      | 3073.0   | 1654.2      |
|       | 3.38E-07  | 1.08E-05  | 1.60E-04  | 1.44E-03  | 8.41E-03  | 3.24E-02  | 7.85E-02  | 1.02E-01    | 3.83E-02    | 1.21E-02 | 1.38E-01    |
|       | .9334     | .9517     | .9745     | 1.0010    | 1.0309    | 1.0644    | 1.1023    | 1.1473      | 1.2136      | 1.1579   | 1.2852      |
|       | 2.65E-01  | 2.65E-01  | 2.63E-01  | 2.61E-01  | 2.58E-01  | 2.53E-01  | 2.47E-01  | 2.38E-01    | 2.22E-01    | 2.35E-01 | 2.02E-01    |
|       | 2.40E-01  | 5.59E+00  | 5.87E+01  | 3.57E+02  | 1.34E+03  | 3.09E+03  | 4.07E+03  | 2.51E+03    | 3.52E+02    | 3.93E+01 | 5.19E+01    |
|       | 2.47E-01* | 5.77E+00* | 6.07E+01* | 3.67E+02* | 1.37E+03* | 3.14E+03  | 4.10E+03  | 2.49E+03    | 3.38E+02    | 4.28E+01 | 5.15E+01    |
| 11    | .5439     | .5981     | .6631     | .7423     | .8412     | .9678     | 1.1358    | 1.3691      | 1.7150      | 2.2806   | 3.3714      |
|       | 18386.5   | 16720.2   | 15081.7   | 13470.9   | 11887.8   | 10332.4   | 8804.4    | 7303.9      | 5830.8      | 4384.9   | 2966.1      |
|       | 9.04E-08  | 2.96E-06  | 4.66E-05  | 4.55E-04  | 3.00E-03  | 1.37E-02  | 4.26E-02  | 8.39E-02    | 8.58E-02    | 1.84E-02 | 2.62E-02    |
|       | .9251     | .9385     | .9572     | .9802     | 1.0068    | 1.0368    | 1.0704    | 1.1087      | 1.1552      | 1.2362   | 1.1883      |
|       | 2.66E-01  | 2.65E-01  | 2.64E-01  | 2.63E-01  | 2.60E-01  | 2.57E-01  | 2.52E-01  | 2.45E-01    | 2.36E-01    | 2.16E-01 | 2.28E-01    |
|       | 8.04E-02  | 1.97E+00  | 2.26E+01  | 1.56E+02  | 6.93E+02  | 2.02E+03  | 3.74E+03  | 3.99E+03    | 1.92E+03    | 1.46E+02 | 7.21E+01    |
|       | 8.24E-02* | 2.03E+00* | 2.34E+01* | 1.61E+02* | 7.12E+02* | 2.07E+03  | 3.80E+03  | 4.01E+03    | 1.89E+03    | 1.37E+02 | 7.57E+01    |
| 12    | .5082     | .5552     | .6108     | .6774     | .7588     | .8603     | .9905     | 1.1635      | 1.4041      | 1.7618   | 2.3490      |
|       | 19677.6   | 18011.2   | 16372.7   | 14762.0   | 13178.9   | 11623.4   | 10095.5   | 8595.0      | 7121.8      | 5675.9   | 4257.2      |
|       | 2.63E-08  | 8.67E-07  | 1.41E-05  | 1.46E-04  | 1.05E-03  | 5.42E-03  | 2.01E-02  | 5.17E-02    | 8.42E-02    | 6.72E-02 | 6.03E-03    |
|       | .9212     | .9295     | .9437     | .9628     | .9859     | 1.0126    | 1.0426    | 1.0764      | 1.1153      | 1.1641   | 1.2830      |
|       | 2.66E-01  | 2.66E-01  | 2.65E-01  | 2.64E-01  | 2.62E-01  | 2.60E-01  | 2.56E-01  | 2.51E-01    | 2.44E-01    | 2.34E-01 | 2.03E-01    |
|       | 2.87E-02  | 7.24E-01  | 8.79E+00  | 6.62E+01  | 3.35E+02  | 1.16E+03  | 2.75E+03  | 4.19E+03    | 3.67E+03    | 1.36E+03 | ( 3.88E+01) |
|       | 2.92E-02* | 7.45E-01* | 9.06E+00* | 6.83E+01* | 3.45E+02* | 1.20E+03* | 2.81E+03  | 4.25E+03    | 3.68E+03    | 1.34E+03 | 3.45E+01*   |
| 13    | .4774     | .5186     | .5668     | .6237     | .6921     | .7756     | .8798     | 1.0136      | 1.1916      | 1.4396   | 1.8091      |
|       | 20948.0   | 19281.7   | 17643.2   | 16032.4   | 14449.3   | 12893.9   | 11365.9   | 9865.4      | 8392.3      | 6946.4   | 5527.6      |
|       | 8.39E-09  | 2.73E-07  | 4.48E-06  | 4.80E-05  | 3.67E-04  | 2.08E-03  | 8.77E-03  | 2.71E-02    | 5.87E-02    | 7.96E-02 | 4.87E-02    |
|       | .9211     | .9248     | .9342     | .9489     | .9683     | .9917     | 1.0184    | 1.0485      | 1.0825      | 1.1222   | 1.1744      |
|       | 2.66E-01  | 2.66E-01  | 2.65E-01  | 2.64E-01  | 2.62E-01  | 2.59E-01  | 2.55E-01  | 2.50E-01    | 2.43E-01    | 2.31E-01 | 2.03E-01    |
|       | 1.10E-02  | 2.80E-01  | 3.51E+00  | 2.81E+01  | 1.56E+02  | 6.20E+02  | 1.75E+03  | 3.44E+03    | 4.40E+03    | 3.19E+03 | 8.92E+02    |
|       | 1.12E-02* | 2.86E-01* | 3.61E+00* | 2.89E+01* | 1.61E+02* | 6.37E+02* | 1.80E+03* | 3.51E+03    | 4.44E+03    | 3.18E+03 | 8.68E+02    |
| 14    | .4505     | .4870     | .5293     | .5786     | .6370     | .7070     | .7926     | .8996       | 1.0371      | 1.2200   | 1.4754      |
|       | 22198.2   | 20531.8   | 18893.3   | 17282.5   | 15699.5   | 14144.0   | 12616.1   | 11115.6     | 9642.4      | 8196.5   | 6777.8      |
|       | 2.93E-09  | 9.34E-08  | 1.52E-06  | 1.65E-05  | 1.31E-04  | 7.92E-04  | 3.67E-03  | 1.30E-02    | 3.41E-02    | 6.30E-02 | 7.12E-02    |
|       | .9240     | .9238     | .9286     | .9389     | .9542     | .9740     | .9974     | 1.0242      | 1.0545      | 1.0888   | 1.1295      |
|       | 2.66E-01  | 2.66E-01  | 2.65E-01  | 2.64E-01  | 2.62E-01  | 2.61E-01  | 2.59E-01  | 2.55E-01    | 2.49E-01    | 2.41E-01 | 2.04E-01    |
|       | 4.59E-03  | 1.16E-01  | 1.47E+00  | 1.22E+01  | 7.20E+01  | 3.15E+02  | 1.02E+03  | 2.41E+03    | 4.02E+03    | 4.36E+03 | 2.62E+03    |
|       | 4.61E-03* | 1.17E-01* | 1.50E+00* | 1.25E+01* | 7.42E+01* | 3.24E+02* | 1.05E+03* | 2.47E+03    | 4.08E+03    | 4.39E+03 | 2.60E+03    |
| 15    | .4268     | .4595     | .4969     | .5402     | .5907     | .6504     | .7222     | .8100       | .9198       | 1.0608   | 1.2488      |
|       | 23428.2   | 21761.9   | 20123.4   | 18512.6   | 16929.5   | 15374.0   | 13846.1   | 12345.6     | 10872.5     | 9426.6   | 8007.8      |
|       | 1.12E-09  | 3.47E-08  | 5.54E-07  | 6.01E-06  | 4.86E-05  | 3.06E-04  | 1.51E-03  | 5.90E-03    | 1.78E-02    | 4.04E-02 | 6.41E-02    |
|       | .9288     | .9257     | .9266     | .9326     | .9437     | .9596     | .9796     | 1.0032      | 1.0301      | 1.0605   | 1.0952      |
|       | 2.66E-01  | 2.66E-01  | 2.65E-01  | 2.65E-01  | 2.64E-01  | 2.63E-01  | 2.61E-01  | 2.58E-01    | 2.54E-01    | 2.48E-01 | 2.48E-01    |
|       | 2.06E-03  | 5.11E-02  | 6.46E-01  | 5.44E+00  | 3.36E+01  | 1.57E+02  | 5.63E+02  | 1.53E+03    | 3.09E+03    | 4.41E+03 | 4.10E+03    |
|       | 2.06E-03* | 5.15E-02* | 6.55E-01* | 5.56E+00* | 3.45E+01* | 1.62E+02* | 5.79E+02* | 1.57E+03*   | 3.15E+03    | 4.48E+03 | 4.11E+03    |

TRANSITION PROBABILITIES AND RELATED DATA FOR NITROGEN AND OXYGEN BANDS 1061

Table 8. Radiative transition parameters for  $\text{N}_2$   $w^{-1}\Delta_u - a^{-1}\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^*(r) R_e(r) \psi_{v''}(r) dr$ . — Continued

| V\W        | 11   | 12  | 13   | 14  | 15   | 16   | 17   | 18                                | 19         | 20         | 21       |
|------------|--|---|--|---|--|--|--|-----------------------------------|------------|------------|----------|
| 8          | -4.1235  | -2.6385   | -1.9500  | -1.5529   | -1.2946  | -1.1132  | -.9789                                       | -.8755                            | -.7935     | -.7269     | -.6717   |
|            | -2425.1  | -3790.0   | -5128.1  | -6439.6   | -7724.7  | -8983.4  | -10215.9                                     | -11422.4                          | -12603.0   | -13757.9   | -14887.0 |
| 1.06E-01   | 2.49E-03   | 8.21E-05  | 3.24E-06   | 3.41E-07  | 5.80E-10   | 3.16E-10   | 1.31E-11                                     | 3.95E-14                          | 3.47E-13   | 3.14E-12   |          |
| 1.6041     | 2.0005   | 1.1705  | 2.1802   | 1.3764  | -1.8714  | 2.4129   | 1.7809                                       | 2.7810                            | .8241      | 1.0572     |          |
| 1.06E-01   | 2.83E-02   | 2.32E-01  | 1.28E-02   | 1.75E-01  | 1.79E-07   | 3.85E-03   | 6.33E-02                                     | 3.82E-04                          | 2.63E-01   | 2.54E-01   |          |
| -3.47E+01  | (-2.20E-01)(-1.21E+00)(-2.88E-04)(-9.74E-03)(-2.74E-17)(-1.01E-08)(-1.59E-07)(-2.34E-14)(-1.27E-07)(-1.35E-06) |   |  | -5.86E-03*  | -1.46E-03*   | -4.82E-05*   | -3.69E-09*                                   | -2.61E-07*                        | -4.98E-07* | -1.62E-06* |          |
| -3.39E+01  | -6.09E-02*   | -1.00E+00*  | -2.33E-02*   | -5.86E-03*  | -1.46E-03*   | -4.82E-05*   | -3.69E-09*                                   | -2.61E-07*                        | -4.98E-07* | -1.62E-06* |          |
| 9          | -9.3402  | -4.1059   | -2.6500  | -1.9665   | -1.5698  | -1.3108  | -1.1285                                      | -.9933                            | -.8890     | -.8062     | -.7390   |
|            | -1070.6  | -2435.5   | -3773.6  | -5085.1   | -6370.2  | -7628.9  | -8861.4                                      | -10067.9                          | -11248.5   | -12403.4   | -13532.6 |
| 4.04E-01   | 1.24E-01   | 2.71E-03  | 1.52E-04   | 3.83E-06  | 6.94E-07   | 3.78E-09   | 6.21E-10                                     | 7.98E-11                          | 5.65E-12   | 7.90E-12   |          |
| 1.4861     | 1.6169   | 2.0597  | 1.2633   | 2.3516  | 1.4579   | -.5022   | 2.5607                                       | 1.6724                            | .9060      | .9222      |          |
| 1.41E-01   | 1.03E-01   | 2.21E-02  | 2.08E-01   | 5.39E-03  | 1.50E-01   | 1.83E-02   | 6.62E-03                                     | 8.82E-02                          | 2.66E-01   | 2.66E-01   |          |
| -2.00E+01  | -3.84E+01  | (-1.44E-01)(-1.76E+00)(-5.84E-05)(-1.40E-02)(-1.80E-06)(-3.36E-09)(-1.79E-06)(-1.55E-06)(-2.80E-06) |  |   |  |  |  |                                   |            |            |          |
| -2.02E+01  | -3.74E+01  | -2.80E-01*  | -1.37E+00*   | -5.73E-02*  | -7.29E-03*   | -2.89E-03*   | -1.31E-04*                                   | -1.94E-07*                        | -3.47E-06* | -4.92E-06* |          |
| 10         | 38.1060  | -9.0707   | -4.0974  | -2.6652   | -1.9853  | -1.5884  | -1.3283                                      | -1.1448                           | -1.0085    | -9.9033    | -8.1917  |
|            | 262.4  | -1102.4   | -2440.6  | -3752.1   | -5037.1  | -6295.8  | -7528.3                                      | -8734.8                           | -9915.5    | -11070.3   | -12199.5 |
| 3.14E-02   | 4.13E-01   | 1.41E-01  | 2.75E-03   | 2.62E-04  | 3.85E-06   | 1.30E-06   | 1.52E-08                                     | 1.06E-09                          | 3.28E-10   | 5.99E-11   |          |
| 1.5209     | 1.4981   | 1.6301  | 2.1338   | 1.3413  | 2.6168   | 1.5363   | .3383  | 2.7504                            | 1.6310     | 1.0395     |          |
| 1.30E-01   | 1.37E-01   | 9.92E-02  | 1.59E-02   | 1.86E-01  | 1.14E-03   | 1.26E-01   | 1.48E-01                                     | 4.72E-04                          | 9.90E-02   | 2.57E-01   |          |
| 1.96E-02   | -2.11E+01  | -4.10E+01   | (-7.46E-02)(-2.33E+00)(-2.53E-06)(-1.78E-02)(-4.52E-04)(-4.68E-10)(-8.83E-06)(-1.45E-05) |   |  |  |  |                                   |            |            |          |
| 1.91E-02   | -2.14E+01  | -3.99E+01   | -7.56E-01*   | -1.75E+00*  | -1.23E-01*   | -7.53E-03*   | -5.18E-03*                                   | -3.18E-04*                        | -1.13E-06* | -1.83E-05* |          |
| 11         | 6.3518   | 47.7377   | -8.8602  | -4.0981   | -2.6844  | -2.0065  | -1.6087                                      | -1.3472                           | -1.1623    | -1.0248    | -9.9185  |
|            | 1574.4   | 209.5   | -1128.6  | -2440.1   | -3725.2  | -4983.9  | -6216.4                                      | -7422.9                           | -8603.5    | -9758.4    | -10887.6 |
| 1.31E-01   | 1.60E-02   | 4.18E-01  | 1.58E-01   | 2.61E-03  | 4.25E-04   | 3.01E-06   | 2.25E-06                                     | 4.77E-08                          | 1.54E-09   | 1.05E-09   |          |
| 1.2931     | 1.6079   | 1.5106  | 1.6438   | 2.2307  | 1.4092   | 3.1058   | 1.6151                                       | .7013                             | 3.0297     | 1.6175     |          |
| 2.00E-01   | 1.05E-01   | 1.33E-01  | 9.56E-02   | 1.01E-02  | 1.65E-01   | 3.28E-05   | 1.03E-01                                     | 2.47E-01                          | 6.04E-05   | 1.03E-01   |          |
| 4.15E+01   | 3.29E-03   | -2.17E+01   | -4.24E+01  | (-2.76E-02)(-2.89E+00)(-1.57E-09)(-1.99E-02)(-3.76E-03)(-1.05E-11)(-2.91E-05) |  |  |  |                                   |            |            |          |
| 4.10E+01   | 3.12E-03   | -2.21E+01   | -4.13E+01  | -1.60E+00*  | -2.11E+00*   | -2.39E-01*   | -5.84E-03*                                   | -8.44E-03*                        | -6.95E-04* | -3.54E-06* |          |
| 12         | 3.4899   | 6.6643  | 61.5707  | -8.7025   | -4.1083  | -2.7080  | -2.0303                                      | -1.6308                           | -1.3675    | -1.1810    | -1.0420  |
|            | 2865.4   | 1500.5  | 162.4  | -1149.1   | -2434.1  | -3692.8  | -4925.3                                      | -6131.8                           | -7312.5    | -8467.4    | -9596.5  |
| 4.11E-02   | 1.20E-01   | 6.63E-03  | 4.21E-01   | 1.73E-01  | 2.26E-03   | 6.56E-04   | 1.40E-06                                     | 3.62E-06                          | 1.27E-07   | 1.71E-09   |          |
| 1.2049     | 1.3007   | 1.7750  | 1.5237   | 1.6580  | 2.3655   | 1.4700   | 4.3941                                       | 1.6977                            | .9457      | 3.5372     |          |
| 2.24E-01   | 1.98E-01   | 6.45E-02  | 1.30E-01   | 9.19E-02  | 5.00E-03   | 1.46E-01   | 4.13E-11                                     | 8.20E-02                          | 2.65E-01   | 6.87E-07   |          |
| 9.84E+01   | 3.20E+01   | (-2.40E-04)   | -2.17E+01  | -4.27E+01   | (-5.76E-03)(-3.38E+00)(-1.12E-21)(-1.93E-02)(-1.10E-02)(-1.45E-15) |  |  |                                   |            |            |          |
| 1.02E+02   | 3.14E+01   | 1.59E-04*   | -2.22E+01  | -4.15E+01   | -2.90E+00*   | -2.40E+00*   | -4.27E-01*                                   | -2.43E-03*                        | -1.25E-02* | -1.39E-03* |          |
| 13         | 2.4179   | 3.6088  | 6.9790   | 82.3968   | -8.5936  | -4.1282  | -2.7361                                      | -2.0570                           | -1.6551    | -1.3895    | -1.2011  |
|            | 4135.9   | 2771.0  | 1432.9   | 121.4   | -1163.7  | -2422.4  | -3654.9                                      | -4861.4                           | -6042.0    | -7196.9    | -8326.0  |
| 5.49E-04   | 5.46E-02   | 1.05E-01  | 1.83E-03   | 4.23E-01  | 1.87E-01   | 1.73E-03   | 9.64E-04                                     | 4.57E-08                          | 5.38E-06   | 3.00E-07   |          |
| 1.5120     | 1.2166   | 1.3082  | 2.2061   | 1.5373  | 1.6727   | 2.5704   | 1.5262                                       | 20.6440                           | 1.7885     | 1.1295     |          |
| 1.33E-01   | 2.21E-01   | 1.95E-01  | 1.13E-02   | 1.25E-01  | 8.81E-02   | 1.52E-03   | 1.29E-01                                     | 0.00E+00                          | 6.17E-02   | 2.41E-01   |          |
| (1.39E+00) | 1.15E+02   | 2.39E+01  | (8.50E-07)   | -2.13E+01   | -4.18E+01  | (-3.99E-04)(-3.72E+00)(0.00E+00)(-1.55E-02)(-2.04E-02) |  |                                   |            |            |          |
| 8.27E-01*  | 1.17E+02   | 2.33E+01  | 3.74E-05*  | -2.19E+01   | -4.06E+01  | -4.75E+00*   | -2.56E+00*                                   | -7.08E-01*                        | -6.45E-11* | -1.66E-02* |          |
| 14         | 1.8567   | 2.4869  | 3.7272   | 7.2914  | 115.6524   | -8.5307  | -4.1584                                      | -2.7691                           | -2.0869    | -1.6816    | -1.4132  |
|            | 5386.0   | 4021.1  | 2683.0   | 1371.5  | 86.5   | -1172.2  | -2404.8                                      | -3611.3                           | -4791.9    | -5946.8    | -7075.9  |
| 3.20E-02   | 6.74E-04   | 6.53E-02  | 8.90E-02   | 1.03E-04  | 4.25E-01   | 1.99E-01   | 1.11E-03                                     | 1.35E-03                          | 1.66E-06   | 7.36E-06   |          |
| 1.1872     | .9086  | 1.2259  | 1.3154   | 5.1641  | 1.5515   | 1.6881   | 2.9285                                       | 1.5794                            | -2.1756    | 1.8941     |          |
| 2.28E-01   | 2.66E-01   | 2.19E-01  | 1.93E-01   | 6.55E-16  | 1.21E-01   | 8.43E-02   | 1.31E-04                                     | 1.13E-01                          | 6.68E-09   | 4.27E-02   |          |
| 5.29E+02   | (6.28E+00)   | 1.22E+02  | 1.74E+01   | (5.78E-35)  | -2.04E+01  | -3.99E+01  | (-1.82E-06)(-3.87E+00)(-3.15E-17)(-9.65E-03) |                                   |            |            |          |
| 5.09E+02   | 1.01E+01*  | 1.24E+02  | 1.68E+01   | 1.21E-04*   | -2.12E+01  | -3.86E+01  | -7.20E+00*                                   | -2.54E+00*                        | -1.10E+00* | -5.92E-03* |          |
| 15         | 1.5115   | 1.9043  | 2.5556   | 3.8439  | 7.5958   | 172.9475   | -8.5128                                      | -4.1996                           | -2.8075    | -2.1201    | -1.7106  |
|            | 6616.0   | 5251.2  | 3913.0   | 2601.5  | 1316.5   | 57.8   | -1174.7                                      | -2381.2                           | -3561.8    | -4716.7    | -5845.9  |
| 6.02E-02   | 1.85E-02   | 4.87E-03  | 7.25E-02   | 7.33E-02  | 2.74E-04   | 4.29E-01   | 2.09E-01                                     | 4.92E-04                          | 1.82E-03   | 1.18E-05   |          |
| 1.1374     | 1.2049   | 1.0952  | 1.2339   | 1.3223  | -1.1354  | 1.5662   | 1.7041                                       | 3.7446                            | 1.6312     | -.0402     |          |
| 2.40E-01   | 2.24E-01   | 2.48E-01  | 2.16E-01   | 1.91E-01  | 1.25E-04   | 1.17E-01   | 8.04E-02                                     | 8.39E-08                          | 9.89E-02   | 5.18E-02   |          |
| 2.03E+03   | 2.72E+02   | (3.63E+01)  | 1.21E+02   | 1.24E+02  | (1.67E-12)   | -1.93E+01  | -3.70E+01                                    | (-3.17E-13)(-3.80E+00)(-1.28E-02) |            |            |          |
| 2.01E+03   | 2.57E+02   | 4.16E+01*   | 1.22E+02   | 1.19E+01  | 8.75E-05*  | -2.02E+01  | -3.58E+01                                    | -1.02E+01                         | -2.32E+00* | -1.62E+00* |          |

Table 9. Radiative transition parameters for  $N_2 C^3\Pi_u - B^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $v'\backslash v''$ | 0        | 1        | 2        | 3           | 4           | 5         | 6         | 7         | 8         | 9         | 10      |
|--------------------|----------|----------|----------|-------------|-------------|-----------|-----------|-----------|-----------|-----------|---------|
| 0                  | .3370    | .3576    | .3804    | .4058       | .4343       | .4665     | .5032     | .5452     | .5938     | .6507     | .7181   |
|                    | 29671.2  | 27965.8  | 26289.6  | 24642.3     | 23024.0     | 21434.7   | 19874.5   | 18343.4   | 16841.6   | 15369.2   | 13926.3 |
| 4.54E-01           | 3.27E-01 | 1.45E-01 | 5.12E-02 | 1.58E-02    | 4.50E-03    | 1.22E-03  | 3.23E-04  | 8.44E-05  | 2.20E-05  | 5.71E-06  |         |
| 1.1843             | 1.1466   | 1.1135   | 1.0830   | 1.0545      | 1.0277      | 1.0025    | .9788     | .9568     | .9359     | .9150     |         |
| 7.40E-01           | 7.81E-01 | 8.12E-01 | 8.37E-01 | 8.56E-01    | 8.70E-01    | 8.79E-01  | 8.85E-01  | 8.87E-01  | 8.86E-01  | 8.83E-01  |         |
| 1.32E+07           | 8.84E+06 | 3.53E+06 | 1.09E+06 | 2.86E+05    | 6.78E+04    | 1.50E+04  | 3.16E+03  | 6.42E+02  | 1.27E+02  | 2.44E+01  |         |
| 1.31E+07           | 8.84E+06 | 3.56E+06 | 1.10E+06 | 2.92E+05    | 6.98E+04*   | 1.55E+04* | 3.29E+03* | 6.74E+02* | 1.34E+02* | 2.59E+01* |         |
| 1                  | .3158    | .3338    | .3536    | .3754       | .3997       | .4268     | .4573     | .4917     | .5309     | .5759     | .6281   |
|                    | 31665.6  | 29960.2  | 28284.0  | 26636.7     | 25018.4     | 23429.1   | 21868.9   | 20337.8   | 18836.0   | 17363.6   | 15920.7 |
| 3.92E-01           | 2.26E-02 | 2.05E-01 | 1.98E-01 | 1.10E-01    | 4.68E-02    | 1.71E-02  | 5.68E-03  | 1.78E-03  | 5.36E-04  | 1.59E-04  |         |
| 1.2285             | 1.2098   | 1.1550   | 1.1211   | 1.0904      | 1.0619      | 1.0354    | 1.0103    | .9844     | .9439     | .9428     |         |
| 6.87E-01           | 7.10E-01 | 7.72E-01 | 8.05E-01 | 8.31E-01    | 8.51E-01    | 8.66E-01  | 8.76E-01  | 8.83E-01  | 8.86E-01  | 8.87E-01  |         |
| 1.19E+07           | 6.19E+05 | 5.60E+06 | 4.93E+06 | 2.41E+06    | 8.84E+05    | 2.72E+05  | 7.44E+04  | 1.88E+04  | 4.47E+03  | 1.02E+03  |         |
| 1.19E+07           | 5.87E+05 | 5.54E+06 | 4.93E+06 | 2.43E+06    | 8.98E+05    | 2.78E+05  | 7.68E+04* | 1.95E+04* | 4.68E+03* | 1.07E+03* |         |
| 2                  | .2976    | .3135    | .3309    | .3499       | .3709       | .3942     | .4200     | .4489     | .4813     | .5180     | .5599   |
|                    | 33606.3  | 31901.0  | 30224.8  | 28577.5     | 26959.2     | 25369.9   | 23809.7   | 22278.6   | 20776.8   | 19304.3   | 17861.5 |
| 1.33E-01           | 3.42E-01 | 2.36E-02 | 6.42E-02 | 1.61E-01    | 1.39E-01    | 7.91E-02  | 3.62E-02  | 1.44E-02  | 5.28E-03  | 1.82E-03  |         |
| 1.2784             | 1.2395   | 1.1679   | 1.1652   | 1.1288      | 1.0976      | 1.0689    | 1.0424    | 1.0177    | .9940     | .9711     |         |
| 6.21E-01           | 6.73E-01 | 7.58E-01 | 7.61E-01 | 7.98E-01    | 8.25E-01    | 8.47E-01  | 8.62E-01  | 8.74E-01  | 8.81E-01  | 8.86E-01  |         |
| 3.94E+06           | 1.02E+07 | 7.58E+05 | 1.76E+06 | 4.07E+06    | 3.13E+06    | 1.55E+06  | 6.02E+05  | 2.00E+05  | 5.97E+04  | 1.65E+04  |         |
| 3.97E+06           | 1.01E+07 | 7.99E+05 | 1.71E+06 | 4.04E+06    | 3.14E+06    | 1.57E+06  | 6.14E+05  | 2.06E+05  | 6.19E+04* | 1.72E+04* |         |
| 3                  | .2818    | .2961    | .3115    | .3284       | .3468       | .3671     | .3894     | .4140     | .4415     | .4722     | .5067   |
|                    | 35480.4  | 33775.1  | 32098.8  | 30451.5     | 28833.2     | 27243.9   | 25683.7   | 24152.6   | 22650.8   | 21178.4   | 19735.5 |
| 2.02E-02           | 2.53E-01 | 2.11E-01 | 8.90E-02 | 5.00E-03    | 9.36E-02    | 1.31E-01  | 9.87E-02  | 5.53E-02  | 2.61E-02  | 1.10E-02  |         |
| 1.3415             | 1.2894   | 1.2551   | 1.1835   | 1.1893      | 1.1362      | 1.1047    | 1.0755    | 1.0487    | 1.0243    | 1.0012    |         |
| 5.35E-01           | 6.07E-01 | 6.52E-01 | 7.41E-01 | 7.34E-01    | 7.91E-01    | 8.20E-01  | 8.42E-01  | 8.59E-01  | 8.71E-01  | 8.79E-01  |         |
| 5.23E+05           | 7.25E+06 | 6.01E+06 | 2.79E+06 | ( 1.31E+05) | 2.40E+06    | 3.02E+06  | 2.00E+06  | 9.61E+05  | 3.82E+05  | 1.33E+05  |         |
| 5.28E+05           | 7.30E+06 | 5.94E+06 | 2.85E+06 | 1.15E+05*   | 2.35E+06    | 3.00E+06  | 2.01E+06  | 9.76E+05  | 3.91E+05  | 1.37E+05  |         |
| 4                  | .2684    | .2812    | .2952    | .3102       | .3266       | .3445     | .3641     | .3856     | .4093     | .4355     | .4648   |
|                    | 37261.7  | 35556.3  | 33880.1  | 32232.8     | 30614.5     | 29025.2   | 27465.0   | 25933.9   | 24432.1   | 22959.7   | 21516.8 |
| 9.50E-04           | 5.37E-02 | 3.30E-01 | 1.19E-01 | 1.16E-01    | 3.48E-03    | 4.02E-02  | 1.01E-01  | 1.01E-01  | 6.80E-02  | 3.72E-02  |         |
| 1.4568             | 1.3575   | 1.3027   | 1.2802   | 1.1862      | 1.1370      | 1.1423    | 1.1110    | 1.0818    | 1.0543    | 1.0295    |         |
| 3.80E-01           | 5.13E-01 | 5.88E-01 | 6.19E-01 | 7.38E-01    | 7.90E-01    | 7.85E-01  | 8.14E-01  | 8.38E-01  | 8.56E-01  | 8.69E-01  |         |
| 1.44E+04           | 1.29E+06 | 8.99E+06 | 3.09E+06 | 3.66E+06    | ( 1.08E+05) | 1.04E+06  | 2.37E+06  | 2.09E+06  | 1.22E+06  | 5.66E+05  |         |
| 1.38E+04*          | 1.30E+06 | 9.03E+06 | 3.02E+06 | 3.71E+06    | 1.24E+05*   | 9.98E+05  | 2.33E+06  | 2.09E+06  | 1.23E+06  | 5.78E+05  |         |

Table 9. Radiative transition parameters for  $N_2 C^3\Pi_u - B^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \backslash v''$ | 11        | 12          | 13          | 14          | 15          | 16          | 17          | 18          | 19          | 20          | 21       |
|---------------------|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----------|
| 0                   | .7992     | .8985       | 1.0228      | 1.1828      | 1.3962      | 1.6944      | 2.1403      | 2.8779      | 4.3302      | 8.4991      | 129.9646 |
| 12513.1             | 11129.9   | 9776.8      | 8454.2      | 7162.4      | 5901.6      | 4672.3      | 3474.7      | 2309.3      | 1176.6      | 76.9        |          |
| 1.46E-06            | 3.68E-07  | 8.99E-08    | 2.11E-08    | 4.65E-09    | 9.03E-10    | 1.19E-10    | 7.67E-13    | 2.08E-11    | 5.49E-11    | 7.33E-11    |          |
| .8925               | .8670     | .8369       | .8004       | .7541       | .6853       | .5188       | .23476      | 1.3805      | 1.1507      | 1.0892      |          |
| 8.77E-01            | 8.67E-01  | 8.50E-01    | 8.24E-01    | 7.81E-01    | 7.04E-01    | 4.80E-01    | 2.31E-16    | 4.81E-01    | 7.77E-01    | 8.32E-01    |          |
| 4.47E+00            | 7.73E-01  | ( 1.23E-01) | ( 1.75E-02) | ( 2.12E-03) | ( 1.86E-04) | ( 5.65E-06) | ( 3.48E-39) | ( 1.20E-07) | ( 1.09E-07) | ( 4.69E-11) |          |
| 4.80E+00*           | 8.44E-01* | 1.38E-01*   | 2.06E-02*   | 2.67E-03*   | 2.71E-04*   | 1.49E-05*   | 1.14E-09*   | 5.27E-07*   | 1.54E-07*   | 5.42E-11*   |          |
| 1                   | .6893     | .7619       | .8495       | .9571       | 1.0921      | 1.2665      | 1.5000      | 1.8285      | 2.3236      | 3.1536      | 4.8278   |
| 14507.5             | 13124.3   | 11771.2     | 10448.6     | 9156.8      | 7896.0      | 6666.7      | 5469.1      | 4303.7      | 3171.0      | 2071.3      |          |
| 4.62E-05            | 1.33E-05  | 3.74E-06    | 1.02E-06    | 2.63E-07    | 6.18E-08    | 1.19E-08    | 1.38E-09    | 2.11E-12    | 2.39E-10    | 5.17E-10    |          |
| .9224               | .9013     | .8782       | .8515       | .8176       | .7675       | .6761       | .4290       | .75517      | 1.4627      | 1.1828      |          |
| 8.85E-01            | 8.80E-01  | 8.72E-01    | 8.59E-01    | 8.37E-01    | 7.95E-01    | 6.92E-01    | 3.62E-01    | 0.00E+00    | 3.73E-01    | 7.42E-01    |          |
| 2.24E+02            | 4.71E+01  | 9.39E+00    | 1.74E+00    | ( 2.87E-01) | ( 3.89E-02) | ( 3.42E-03) | ( 6.00E-05) | ( 0.00E+00) | ( 2.14E-06) | ( 5.12E-06) |          |
| 2.37E+02*           | 5.03E+01* | 1.02E+01*   | 1.92E+00*   | 3.29E-01*   | 4.85E-02*   | 5.42E-03*   | 3.13E-04*   | 1.60E-07*   | 1.59E-05*   | 8.44E-06*   |          |
| 2                   | .6080     | .6638       | .7293       | .8071       | .9011       | 1.0166      | 1.1618      | 1.3495      | 1.6014      | 1.9563      | 2.4924   |
| 16448.3             | 15065.1   | 13712.0     | 12389.4     | 11097.6     | 9836.8      | 8607.5      | 7409.9      | 6244.5      | 5111.8      | 4012.1      |          |
| 6.03E-04            | 1.96E-04  | 6.21E-05    | 1.91E-05    | 5.70E-06    | 1.61E-06    | 4.21E-07    | 9.26E-08    | 1.33E-08    | 2.81E-10    | 8.61E-10    |          |
| .9497               | .9295     | .9092       | .8866       | .8604       | .8288       | .7860       | .7107       | .5141       | -1.1337     | 1.7548      |          |
| 8.87E-01            | 8.86E-01  | 8.82E-01    | 8.75E-01    | 8.64E-01    | 8.45E-01    | 8.12E-01    | 7.34E-01    | 4.74E-01    | 5.31E-07    | 1.05E-01    |          |
| 4.28E+03            | 1.06E+03  | 2.52E+02    | 5.65E+01    | 1.18E+01    | ( 2.22E+00) | ( 3.58E-01) | ( 4.12E-02) | ( 1.48E-03) | 2.14E-17    | ( 1.23E-06) |          |
| 4.49E+03*           | 1.12E+03* | 2.68E+02*   | 6.08E+01*   | 1.29E+01*   | 2.52E+00*   | 4.32E-01*   | 5.88E-02*   | 4.80E-03*   | 3.58E-05*   | 1.11E-04*   |          |
| 3                   | .5458     | .5904       | .6416       | .7011       | .7709       | .8539       | .9541       | 1.0771      | 1.2317      | 1.4315      | 1.6989   |
| 18322.3             | 16939.1   | 15586.1     | 14263.5     | 12971.6     | 11710.8     | 10481.5     | 9283.9      | 8118.6      | 6985.8      | 5886.2      |          |
| 4.30E-03            | 1.58E-03  | 5.64E-04    | 1.96E-04    | 6.62E-05    | 2.14E-05    | 6.51E-06    | 1.84E-06    | 4.71E-07    | 9.77E-08    | 1.09E-08    |          |
| .9785               | .9562     | .9355       | .9161       | .8955       | .8701       | .8367       | .7939       | .7359       | .6319       | .2939       |          |
| 8.85E-01            | 8.87E-01  | 8.86E-01    | 8.84E-01    | 8.78E-01    | 8.68E-01    | 8.50E-01    | 8.18E-01    | 7.62E-01    | 6.35E-01    | 2.14E-01    |          |
| 4.19E+04            | 1.25E+04  | 5.40E+03    | 9.00E+02    | 2.26E+02    | 5.25E+01    | ( 1.10E+01) | ( 2.00E+00) | ( 2.97E-01) | ( 2.72E-02) | ( 2.07E-04) |          |
| 4.36E+04*           | 1.29E+04* | 3.59E+03*   | 9.55E+02*   | 2.42E+02*   | 5.72E+01*   | 1.25E+01*   | 2.43E+00*   | 4.02E-01*   | 4.96E-02*   | 2.80E-03*   |          |
| 4                   | .4974     | .5342       | .5758       | .6233       | .6778       | .7412       | .8155       | .9037       | 1.0101      | 1.1406      | 1.3042   |
| 20103.6             | 18720.4   | 17567.3     | 16044.7     | 14752.9     | 13492.1     | 12262.8     | 11065.2     | 9899.8      | 8767.1      | 7667.4      |          |
| 1.79E-02            | 7.80E-03  | 3.17E-03    | 1.22E-03    | 4.58E-04    | 1.68E-04    | 5.96E-05    | 2.00E-05    | 6.13E-06    | 1.69E-06    | 4.09E-07    |          |
| 1.0071              | .9855     | .9632       | .9409       | .9201       | .9012       | .8810       | .8530       | .8099       | .7459       | .6554       |          |
| 8.78E-01            | 8.83E-01  | 8.86E-01    | 8.87E-01    | 8.84E-01    | 8.80E-01    | 8.73E-01    | 8.60E-01    | 8.31E-01    | 7.73E-01    | 6.66E-01    |          |
| 2.26E+05            | 8.09E+04  | 2.65E+04    | 8.05E+03    | 2.33E+03    | 6.47E+02    | 1.70E+02    | 4.06E+01    | ( 8.33E+00) | ( 1.38E+00) | ( 1.66E-01) |          |
| 2.32E+05            | 8.37E+04* | 2.76E+04*   | 8.50E+03*   | 2.48E+03*   | 6.91E+02*   | 1.83E+02*   | 4.47E+01*   | 9.85E+00*   | 1.88E+00*   | 2.97E-01*   |          |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 10. Radiative transition parameters for  $N_2 E^3\Sigma_g^+ - A^3\Sigma_u^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $v' \backslash v''$ | 0        | 1        | 2           | 3           | 4           | 5           | 6           | 7           | 8           | 9           | 10    |
|---------------------|----------|----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------|
| 0                   | .2173    | .2243    | .2316       | .2392       | .2472       | .2555       | .2643       | .2734       | .2830       | .2930       | .3035 |
| 46019.7             | 44586.8  | 43181.6  | 41804.1     | 40454.5     | 39132.8     | 37839.2     | 36574.0     | 35337.4     | 34129.7     | 32951.4     |       |
| 3.98E-03            | 1.72E-02 | 4.02E-02 | 6.78E-02    | 9.24E-02    | 1.08E-01    | 1.13E-01    | 1.08E-01    | 9.71E-02    | 8.24E-02    | 6.70E-02    |       |
| 1.1969              | 1.1845   | 1.1727   | 1.1615      | 1.1508      | 1.1406      | 1.1309      | 1.1216      | 1.1127      | 1.1042      | 1.0960      |       |
| 1.28E-02            | 1.10E-02 | 9.16E-03 | 7.52E-03    | 6.07E-03    | 4.84E-03    | 3.82E-03    | 2.99E-03    | 2.33E-03    | 1.80E-03    | 1.39E-03    |       |
| ( 1.29E+02)         | 3.71E+02 | 5.51E+02 | ( 5.67E+02) | ( 4.57E+02) | ( 3.08E+02) | ( 1.82E+02) | 9.64E+01    | ( 4.71E+01) | ( 2.16E+01) | ( 9.34E+00) |       |
| 1.14E+02*           | 3.59E+02 | 5.77E+02 | 6.32E+02    | 5.28E+02    | 3.58E+02    | 2.04E+02    | 9.95E+01    | 4.22E+01    | 1.56E+01    | 4.96E+00    |       |
| 1                   | .2074    | .2138    | .2204       | .2273       | .2345       | .2420       | .2498       | .2580       | .2665       | .2754       | .2846 |
| 48204.7             | 46771.8  | 45366.6  | 43989.1     | 42639.5     | 41317.8     | 40024.2     | 38759.0     | 37522.4     | 36314.7     | 35136.4     |       |
| 2.67E-02            | 7.81E-02 | 1.18E-01 | 1.18E-01    | 8.55E-02    | 4.27E-02    | 1.14E-02    | 9.06E-05    | 5.64E-03    | 2.00E-02    | 3.56E-02    |       |
| 1.2159              | 1.2027   | 1.1901   | 1.1782      | 1.1666      | 1.1553      | 1.1431      | 1.0924      | 1.1337      | 1.1221      | 1.1128      |       |
| 1.53E-02            | 1.36E-02 | 1.18E-02 | 1.00E-02    | 8.25E-03    | 6.66E-03    | 5.13E-03    | 1.23E-03    | 4.10E-03    | 3.03E-03    | 2.33E-03    |       |
| ( 1.42E+03)         | 3.01E+03 | 3.11E+03 | 2.04E+03    | 9.15E+02    | 2.71E+02    | ( 3.91E+01) | ( 1.62E-02) | ( 1.02E+01) | ( 1.79E+01) | ( 1.71E+01) |       |
| 1.19E+03            | 2.75E+03 | 3.07E+03 | 2.12E+03    | 9.54E+02    | 2.48E+02    | 1.73E+01    | 8.68E+00*   | 3.79E+01*   | 4.52E+01    | 3.43E+01    |       |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 11. Radiative transition parameters for  $N_2 E^3\Sigma_g^+ - B^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units), and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $v' \backslash v''$ | 0        | 1         | 2        | 3        | 4        | 5        | 6        | 7         | 8         | 9         | 10    |
|---------------------|----------|-----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-------|
| 0                   | .2742    | .2877     | .3022    | .3181    | .3353    | .3542    | .3749    | .3978     | .4230     | .4511     | .4826 |
| 36467.8             | 34762.5  | 33086.2   | 31438.9  | 29820.6  | 28231.3  | 26671.1  | 25140.0  | 23638.2   | 22165.8   | 20722.9   |       |
| 1.43E-01            | 2.43E-01 | 2.35E-01  | 1.70E-01 | 1.03E-01 | 5.54E-02 | 2.75E-02 | 1.29E-02 | 5.77E-03  | 2.52E-03  | 1.07E-03  |       |
| 1.1653              | 1.1431   | 1.1224    | 1.1031   | 1.0848   | 1.0675   | 1.0512   | 1.0357   | 1.0209    | 1.0069    | .9934     |       |
| 1.85E-03            | 1.85E-03 | 1.85E-03  | 1.85E-03 | 1.85E-03 | 1.85E-03 | 1.85E-03 | 1.85E-03 | 1.85E-03  | 1.85E-03  | 1.85E-03  |       |
| 9.63E+01            | 1.42E+02 | 1.18E+02  | 7.32E+01 | 3.78E+01 | 1.73E+01 | 7.23E+00 | 2.83E+00 | 1.06E+00* | 3.80E-01* | 1.33E-01* |       |
| 1                   | .2587    | .2707     | .2835    | .2974    | .3124    | .3288    | .3465    | .3660     | .3872     | .4107     | .4365 |
| 38652.8             | 36947.5  | 35271.2   | 33623.9  | 32005.6  | 30416.3  | 28856.1  | 27325.0  | 25823.2   | 24350.8   | 22907.9   |       |
| 3.11E-01            | 1.26E-01 | 7.28E-04  | 4.83E-02 | 1.16E-01 | 1.31E-01 | 1.06E-01 | 7.16E-02 | 4.27E-02  | 2.34E-02  | 1.21E-02  |       |
| 1.1937              | 1.1683   | 1.1115    | 1.1324   | 1.1112   | 1.0924   | 1.0749   | 1.0585   | 1.0429    | 1.0282    | 1.0142    |       |
| 1.85E-03            | 1.85E-03 | 1.85E-03  | 1.85E-03 | 1.85E-03 | 1.85E-03 | 1.85E-03 | 1.85E-03 | 1.85E-03  | 1.85E-03  | 1.85E-03  |       |
| 2.49E+02            | 8.80E+01 | 4.43E-01* | 2.55E+01 | 5.26E+01 | 5.10E+01 | 3.54E+01 | 2.03E+01 | 1.02E+01  | 4.68E+00  | 2.01E+00  |       |

\*The Einstein coefficient for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

**TRANSITION PROBABILITIES AND RELATED DATA FOR NITROGEN AND OXYGEN BANDS 1065**

Table 12. Radiative transition parameters for  $N_2 E^3\Sigma_g^+ - C^3\Pi_u$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units), and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $V' \backslash V''$ | 0        | 1        | 2        | 3         | 4          |
|---------------------|----------|----------|----------|-----------|------------|
| 0                   | 1.4713   | 2.0824   | 3.4947   | 10.1275   | -12.5965   |
|                     | 6796.6   | 4802.2   | 2861.4   | 987.4     | -793.9     |
|                     | 7.75E-01 | 1.87E-01 | 3.20E-02 | 5.01E-03  | 7.94E-04   |
|                     | 1.1359   | 1.0720   | 1.0185   | .9741     | .9362      |
|                     | 4.14E-02 | 4.14E-02 | 4.14E-02 | 4.14E-02  | 4.14E-02   |
|                     | 1.69E+03 | 1.44E+02 | 5.20E+00 | 3.35E-02* | -1.38E-03* |
| 1                   | 1.1134   | 1.4312   | 1.9816   | 3.1522    | 7.1884     |
|                     | 8981.6   | 6987.2   | 5046.4   | 3172.4    | 1391.1     |
|                     | 2.05E-01 | 4.23E-01 | 2.72E-01 | 7.73E-02  | 1.75E-02   |
|                     | 1.2059   | 1.1460   | 1.0810   | 1.0273    | .9838      |
|                     | 4.14E-02 | 4.14E-02 | 4.14E-02 | 4.14E-02  | 4.14E-02   |
|                     | 1.03E+03 | 1.00E+03 | 2.43E+02 | 1.71E+01  | 3.27E-01   |

\*The Einstein coefficient for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 13. Radiative transition parameters for  $N_2 D^3\Sigma_u^+ - B^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $V' \backslash V''$ | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9         | 10        |
|---------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|
| 0                   | .2259    | .2350    | .2446    | .2549    | .2658    | .2776    | .2901    | .3036    | .3181    | .3338     | .3506     |
|                     | 44264.1  | 42558.8  | 40882.6  | 39235.3  | 37617.0  | 36027.7  | 34467.5  | 32936.4  | 31434.6  | 29962.1   | 28519.3   |
|                     | 9.71E-02 | 1.93E-01 | 2.17E-01 | 1.83E-01 | 1.30E-01 | 8.14E-02 | 4.69E-02 | 2.55E-02 | 1.32E-02 | 6.67E-03  | 3.29E-03  |
|                     | 1.1608   | 1.1403   | 1.1215   | 1.1040   | 1.0876   | 1.0722   | 1.0576   | 1.0439   | 1.0310   | 1.0187    | 1.0071    |
|                     | 6.09E-01 | 5.69E-01 | 5.31E-01 | 4.95E-01 | 4.61E-01 | 4.29E-01 | 4.00E-01 | 3.72E-01 | 3.47E-01 | 3.24E-01  | 3.03E-01  |
|                     | 1.27E+07 | 1.95E+07 | 1.70E+07 | 1.10E+07 | 5.95E+06 | 2.84E+06 | 1.24E+06 | 5.11E+05 | 2.01E+05 | 7.63E+04  | 2.83E+04  |
|                     | 1.25E+07 | 1.94E+07 | 1.70E+07 | 1.10E+07 | 5.96E+06 | 2.84E+06 | 1.24E+06 | 5.07E+05 | 1.98E+05 | 7.46E+04* | 2.74E+04* |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 14. Radiative transition parameters for  $N_2^+ A\ ^2\Pi_u - X\ ^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $v'\backslash v''$ | 0  | 1   | 2   | 3  | 4   | 5   | 6   | 7  | 8   | 9   | 10  |
|--------------------|--|---|---|--|---|---|---|--|---|---|---|
| 0                  | 1.1092<br>9015.6<br>4.81E-01<br>1.1491<br>2.55E-01<br>4.65E+04<br>4.64E+04 | 1.4618<br>6840.7<br>3.78E-01<br>1.1924<br>2.46E-01<br>1.48E+04<br>1.48E+04  | 2.1284<br>4698.4<br>1.20E-01<br>1.2406<br>2.34E-01<br>1.38E+03<br>1.39E+03  | 3.8625<br>2589.0<br>1.95E-02<br>1.2954<br>2.20E-01<br>3.34E+01<br>3.36E+01 | 19.5110<br>512.5<br>1.73E-03<br>1.3612<br>2.02E-01<br>1.93E-02<br>1.95E-02* | -6.5328<br>-1530.7<br>7.89E-05<br>1.4468<br>1.78E-01<br>-3.64E-02<br>-3.67E-02* | -2.8244<br>-3540.5<br>1.54E-06<br>1.5782<br>1.41E-01<br>-5.50E-03<br>-5.42E-03* | -1.8127<br>-5516.6<br>5.96E-09<br>1.9443<br>5.72E-02<br>(-1.33E-05)<br>(-5.42E-03* | -1.3407<br>-7458.6<br>4.07E-11<br>1.0324<br>2.75E-01<br>(-5.19E-06)<br>(-5.77E-08)  | -1.0677<br>-9366.2<br>1.63E-12<br>1.7225<br>1.03E-01<br>(-5.19E-06)<br>(-3.71E-08*) | -0.8898<br>-11239.1<br>2.57E-14<br>.9275<br>2.86E-01<br>(-1.20E-08)<br>(-1.54E-08*) |
| 1                  | .9183<br>10889.2<br>3.24E-01<br>1.1118<br>2.63E-01<br>5.84E+04<br>5.85E+04 | 1.1475<br>8714.3<br>3.45E-02<br>1.1669<br>2.51E-01<br>2.93E+03<br>2.87E+03  | 1.5216<br>6572.0<br>3.41E-01<br>1.2010<br>2.32E-01<br>1.17E+04<br>1.16E+04  | 2.2409<br>4462.6<br>2.33E-01<br>1.2484<br>2.18E-01<br>2.27E+03<br>2.28E+03 | 4.1909<br>2386.1<br>5.94E-02<br>1.3033<br>2.00E-01<br>7.79E+01<br>7.84E+01  | 29.1662<br>342.9<br>7.10E-03<br>1.3696<br>1.75E-01<br>2.32E-02<br>2.34E-02*     | -5.9990<br>-1666.9<br>4.01E-04<br>1.4569<br>1.36E-01<br>-2.31E-01<br>-2.33E-01* | -2.7450<br>-3643.0<br>8.92E-06<br>1.5946<br>1.36E-01<br>-3.25E-02<br>-3.17E-02*    | -1.7905<br>-5585.0<br>3.08E-08<br>2.0361<br>4.31E-02<br>(-4.04E-05)<br>(-9.82E-08*) | -1.3346<br>-7492.6<br>4.86E-10<br>1.1718<br>2.50E-01<br>8.31E-02<br>-5.41E-05*      | -1.0678<br>-9365.5<br>1.26E-11<br>1.8097<br>8.31E-02<br>(-2.90E-07)<br>(-1.26E-07*) |
| 2                  | .7854<br>12732.8<br>1.33E-01<br>1.0783<br>2.68E-01<br>4.02E+04<br>4.04E+04 | .9472<br>10557.8<br>2.28E-01<br>1.1203<br>2.57E-01<br>3.70E+04<br>3.68E+04  | 1.1883<br>8415.6<br>1.87E-02<br>1.1401<br>2.41E-01<br>1.49E+03<br>1.53E+03  | 1.5858<br>6306.1<br>1.95E-01<br>1.2113<br>1.2567<br>5.77E+03<br>5.73E+03   | 2.3643<br>4229.7<br>2.95E-01<br>1.2113<br>1.3113<br>2.40E+03<br>2.40E+03    | 4.5737<br>2186.4<br>1.12E-01<br>1.2113<br>1.3782<br>1.11E+02<br>1.11E+02        | 56.6248<br>176.6<br>1.74E-02<br>1.3113<br>1.4674<br>7.67E-03<br>7.67E-03        | -5.5572<br>-1799.5<br>1.18E-03<br>1.3782<br>1.6126<br>-8.34E-01*<br>-8.34E-01*     | -2.6728<br>-3741.5<br>2.91E-05<br>1.6126<br>2.1725<br>-1.03E-01*<br>-1.03E-01*      | -1.7702<br>-5649.1<br>8.11E-08<br>2.1725<br>1.2772<br>2.25E-01<br>-8.56E-05*        | -1.3294<br>-7521.9<br>2.99E-09<br>1.2772<br>1.2772<br>2.25E-01<br>-2.58E-04*        |
| 3                  | .6875<br>14546.3<br>4.39E-02<br>1.0480<br>2.73E-01<br>2.04E+04<br>2.06E+04 | .8083<br>12371.3<br>1.97E-01<br>1.0858<br>2.67E-01<br>5.40E+04<br>5.41E+04  | .9776<br>10229.1<br>8.34E-02<br>1.1315<br>2.59E-01<br>1.21E+04<br>1.20E+04  | 1.2316<br>8119.6<br>1.01E-01<br>1.1592<br>2.53E-01<br>6.99E+03<br>7.05E+03 | 1.6548<br>6043.2<br>7.14E-02<br>1.2258<br>2.38E-01<br>1.81E+03<br>1.78E+03  | 2.5001<br>3999.9<br>3.00E-01<br>1.2258<br>2.28E-01<br>2.02E+03<br>2.02E+03      | 5.0249<br>1990.1<br>1.68E-01<br>1.2258<br>2.1397<br>1.22E+02<br>1.23E+02        | 712.1493<br>14.0<br>3.32E-02<br>1.3871<br>1.95E-01<br>7.09E-06<br>7.15E-06         | -5.1868<br>-1928.0<br>2.64E-03<br>1.4785<br>1.69E-01<br>-2.19E+00<br>-2.21E+00*     | -2.6072<br>-3835.6<br>7.01E-05<br>1.6326<br>1.26E-01<br>-2.54E-01<br>-2.44E-01*     | -1.7518<br>-5708.4<br>1.34E-07<br>2.4033<br>1.11E-02<br>(-1.25E-05)<br>-1.13E-03*   |
| 4                  | .6124<br>16329.7<br>1.29E-02<br>1.0202<br>2.77E-01<br>8.70E+03<br>8.78E+03 | .7065<br>14154.8<br>1.01E-01<br>1.0552<br>2.72E-01<br>4.30E+04<br>4.32E+04  | .8325<br>12012.5<br>8.57E-03<br>1.0939<br>2.66E-01<br>1.08E+03<br>1.03E+03* | 1.0098<br>9903.1<br>1.54E-01<br>1.1601<br>2.53E-01<br>9.39E+03<br>9.41E+03 | 1.2777<br>7826.6<br>1.54E-01<br>1.1694<br>2.51E-01<br>9.46E+02<br>1.84E+02* | 1.7291<br>5783.4<br>1.95E-03<br>1.2647<br>2.28E-01<br>1.46E+03<br>1.45E+03      | 2.6500<br>3773.6<br>2.63E-01<br>1.2752<br>2.26E-01<br>1.22E+02<br>1.21E+02      | 5.5633<br>1797.5<br>2.18E-01<br>1.3285<br>1.3285<br>1.3964<br>1.4902               | -69.2094<br>-144.5<br>5.41E-02<br>1.4902<br>1.6551<br>1.66E-01<br>1.20E-01          | -4.8731<br>-2052.1<br>4.96E-03<br>1.6551<br>1.6551<br>1.20E-01<br>-4.77E+00         | -2.5478<br>-3925.0<br>1.38E-04<br>1.20E-01<br>1.20E-01<br>-4.87E-01<br>-4.62E-01*   |
| 5                  | .5530<br>18083.2<br>3.55E-03<br>.9948<br>2.80E-01<br>3.32E+03<br>3.35E+03* | .6286<br>15908.2<br>4.04E-02<br>1.0273<br>2.76E-01<br>2.51E+04<br>2.53E+04  | .7264<br>13766.0<br>1.37E-01<br>1.0627<br>2.71E-01<br>2.64E-01<br>2.41E-04  | .8579<br>11656.5<br>1.09E-01<br>1.0980<br>1.0980<br>7.12E+02<br>7.55E+02*  | 1.0438<br>9580.1<br>5.69E-03<br>1.1032<br>1.0980<br>8.24E+03<br>8.21E+03    | 1.3268<br>7536.8<br>1.53E-01<br>1.1789<br>1.1789<br>5.90E+01<br>6.57E+01*       | 1.8093<br>5527.0<br>2.57E-03<br>1.1286<br>1.1286<br>9.19E+02<br>9.13E+02        | 2.8161<br>3551.0<br>2.04E-01<br>1.2860<br>1.2860<br>9.47E+01<br>9.49E+01           | 6.2152<br>1609.0<br>2.57E-01<br>1.3376<br>1.3376<br>9.47E+01<br>9.49E+01            | -33.4835<br>-298.7<br>7.91E-02<br>1.4060<br>1.5025<br>-3.07E-01<br>-8.98E+00        | -4.6051<br>-2171.5<br>8.23E-03<br>1.5025<br>1.5025<br>-8.98E+00<br>-9.02E+00*       |
| 6                  | .5049<br>19806.6<br>9.44E-04<br>.9717<br>2.82E-01<br>1.18E+03<br>1.20E+03* | .5672<br>17631.7<br>1.42E-02<br>1.0019<br>2.75E-01<br>2.13E+04<br>2.14E+04  | .6456<br>15489.4<br>7.35E-02<br>1.0346<br>2.70E-01<br>4.19E+04<br>4.21E+04  | .7474<br>13380.0<br>1.39E-01<br>1.0706<br>2.62E-01<br>4.89E+04<br>4.89E+04 | .8847<br>11303.5<br>4.47E-02<br>1.1156<br>2.59E-01<br>8.97E+03<br>8.81E+03  | 1.0799<br>9260.2<br>4.03E-02<br>1.1156<br>2.59E-01<br>4.43E+03<br>4.53E+03      | 1.3792<br>7250.4<br>1.17E-01<br>1.1298<br>2.47E-01<br>5.43E+03<br>5.43E+03      | 1.8960<br>5274.4<br>2.87E-02<br>1.1891<br>2.43E-01<br>5.19E+02<br>5.19E+02         | 3.0009<br>3332.4<br>1.40E-01<br>1.2030<br>2.19E-01<br>7.04E+01<br>7.05E+01          | 7.0187<br>1424.8<br>2.83E-01<br>1.2988<br>1.3473<br>2.06E-01<br>-22.3168            | -22.3168<br>-448.1<br>1.07E-01<br>1.4160<br>1.87E-01<br>-1.36E+00<br>-1.37E+00      |
| 7                  | .4651<br>21500.0<br>2.52E-04<br>.9510<br>2.84E-01<br>4.09E+02<br>4.15E+02* | .5175<br>19325.1<br>4.62E-03<br>1.0091<br>2.78E-01<br>5.36E+03<br>5.42E+03* | .5820<br>17182.8<br>3.22E-02<br>1.0421<br>2.74E-01<br>5.17E+04<br>5.19E+04  | .6634<br>15073.4<br>9.93E-02<br>1.0421<br>2.68E-01<br>3.55E+04<br>3.53E+04 | .7694<br>12996.9<br>1.11E-01<br>1.0791<br>2.68E-01<br>1.30E+03<br>1.23E+03* | .9129<br>10953.7<br>7.41E-03<br>1.1434<br>2.57E-01<br>7.50E+03<br>7.57E+03      | 1.1181<br>8943.9<br>1.1891<br>1.1420<br>2.44E-01<br>2.80E+03<br>2.75E+03        | 1.4352<br>6967.8<br>1.2030<br>1.2012<br>2.39E-01<br>9.69E+02<br>9.83E+02           | 1.9897<br>5025.8<br>1.2988<br>1.2209<br>2.15E-01<br>2.39E+02<br>2.35E+02            | 3.2070<br>3118.2<br>1.3473<br>1.3151<br>2.03E-01<br>4.77E+01<br>4.77E+01            | 8.0300<br>1245.3<br>1.4160<br>1.3574<br>2.03E-01<br>4.77E+01<br>4.77E+01            |

## TRANSITION PROBABILITIES AND RELATED DATA FOR NITROGEN AND OXYGEN BANDS 1067

Table 14. Radiative transition parameters for  $N_2^+ A^2\Pi_u - X^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $v' \setminus v''$ | 11   | 12  | 13  | 14  | 15                     | 16         | 17         | 18                     | 19         | 20          | 21         |
|--------------------|--|---|---|---|------------------------|------------|------------|------------------------|------------|-------------|------------|
| 0                  | -.7647                                       | -.6721  | -.6008  | -.5442  | -.4983                 | -.4603     | -.4285     | -.4013                 | -.3780     | -.3578      | -.3400     |
|                    | -13076.8                                     | -14879.1  | -16645.3  | -18375.2  | -20068.0               | -21723.1   | -23339.9   | -24917.5               | -26455.3   | -27952.5    | -29408.6   |
|                    | 7.61E-17                                     | 1.70E-18  | 4.72E-17  | 6.30E-19  | 1.00E-16               | 2.41E-16   | 1.57E-16   | 1.00E-17               | 1.57E-17   | 7.02E-17    | 6.75E-17   |
|                    | -1.2837                                      | 4.2135  | 1.4356  | 3.0535  | 1.0337                 | 1.0886     | 1.0873     | 1.0171                 | 1.2225     | 1.1519      | 1.1283     |
|                    | 6.17E-04                                     | 6.71E-08  | 1.81E-01  | 4.10E-04  | 2.75E-01               | 2.67E-01   | 2.77E-01   | 2.39E-01               | 2.55E-01   | 2.59E-01    |            |
|                    | (-2.62E-16)(-1.02E-25)(-2.90E-11)(-2.66E-18) | -2.48E-10   | -7.12E-10   | -5.76E-10   | -8.69E-11              | -6.72E-11  | -4.03E-10  | -4.68E-10              |            |             |            |
|                    | -5.40E-10*                                   | -3.11E-13*  | -4.83E-11*  | -4.15E-14*  | -2.37E-10*             | -6.93E-10* | -5.64E-10* | -8.53E-11*             | -7.10E-11* | -4.08E-10*  | -4.72E-10* |
| 1                  | -.8926                                       | -.7689  | -.6770  | -.6060  | -.5496                 | -.5038     | -.4658     | -.4340                 | -.4068     | -.3835      | -.3632     |
|                    | -11203.2                                     | -13005.5  | -14771.7  | -16501.6  | -18194.4               | -19849.5   | -21466.3   | -23043.9               | -24581.7   | -26078.9    | -27535.0   |
|                    | 3.28E-13                                     | 1.47E-16  | 4.52E-16  | 1.06E-15  | 1.16E-15               | 9.23E-16   | 4.87E-16   | 1.33E-16               | 2.68E-18   | 3.16E-17    | 8.60E-17   |
|                    | 1.0566                                       | -5.2039   | .3229   | .8980   | .9546                  | .9754      | .9758      | .9411                  | .4251      | 1.2104      | 1.1392     |
|                    | 2.72E-01                                     | 9.37E-23  | 1.98E-01  | 2.87E-01  | 2.84E-01               | 2.82E-01   | 2.82E-01   | 2.85E-01               | 2.26E-01   | 2.42E-01    | 2.57E-01   |
|                    | -1.38E-07                                    | (0.00E+00)(-2.31E-10)   | -1.59E-09   | -2.28E-09   | -2.32E-09              | -1.55E-09  | -5.36E-10  | (-8.23E-12)(-1.33E-10) | -4.82E-10  |             |            |
|                    | -1.49E-07*                                   | -4.79E-09*  | -8.38E-10*  | -1.46E-09*  | -2.18E-09*             | -2.26E-09* | -1.51E-09* | -5.22E-10*             | -1.67E-11* | -1.52E-10*  | -5.04E-10* |
| 2                  | -1.0684                                      | -.8959  | -.7735  | -.6822  | -.6116                 | -.5554     | -.5096     | -.4717                 | -.4398     | -.4126      | -.3892     |
|                    | -9359.7                                      | -11161.9  | -12928.2  | -14658.0  | -16350.8               | -18006.0   | -19622.7   | -21200.4               | -22738.1   | -24235.3    | -25691.4   |
|                    | 4.80E-11                                     | 2.62E-12  | 1.69E-14  | 1.21E-14  | 1.24E-14               | 6.32E-15   | 2.72E-15   | 1.21E-15               | 4.52E-16   | 5.50E-17    | 2.87E-17   |
|                    | 1.9307                                       | 1.1746  | -.3734  | .6427   | .9225                  | .9056      | .8734      | .8827                  | .9032      | .7732       | 1.4509     |
|                    | 5.95E-02                                     | 2.05E-01  | 3.82E-02  | 2.72E-01  | 2.86E-01               | 2.87E-01   | 2.88E-01   | 2.88E-01               | 2.87E-01   | 2.86E-01    | 1.77E-01   |
|                    | (-5.65E-07)                                  | -9.20E-07   | (-2.15E-10)(-1.14E-08)                                  | -1.79E-08   | -1.23E-08              | -6.90E-09  | -3.86E-09  | -1.77E-09              | -2.59E-10  | (-6.16E-11) |            |
|                    | -4.05E-08*                                   | -8.90E-07*  | -6.30E-08*  | -1.79E-08*  | -1.67E-08*             | -1.20E-08* | -7.00E-09* | -3.83E-09*             | -1.67E-09* | -2.45E-10*  | -1.15E-10* |
| 3                  | -1.3252                                      | -1.0697   | -.8997  | -.7785  | -.6879                 | -.6176     | -.5615     | -.5158                 | -.4779     | -.4460      | -.4188     |
|                    | -7546.2                                      | -9348.4   | -11114.7  | -12844.5  | -14537.3               | -16192.5   | -17809.2   | -19386.9               | -20924.6   | -22421.8    | -23877.9   |
|                    | 1.25E-08                                     | 1.14E-10  | 1.44E-11  | 2.28E-13  | 6.58E-14               | 5.11E-14   | 2.62E-14   | 1.24E-14               | 5.30E-15   | 1.47E-15    | 1.01E-16   |
|                    | 1.3634                                       | 2.1111  | 1.2696  | .2921   | .5871                  | .8680      | .8777      | .8741                  | .8749      | .8096       | .2840      |
|                    | 2.02E-01                                     | 3.36E-02  | 2.27E-01  | 1.89E-01  | 2.62E-01               | 2.88E-01   | 2.88E-01   | 2.88E-01               | 2.87E-01   | 2.87E-01    | 1.87E-01   |
|                    | -8.89E-04                                    | (-4.29E-07)(-4.14E-06)(-7.01E-08)(-5.64E-08)  | -7.29E-08   | -4.97E-08   | -3.03E-08              | -1.63E-08  | -5.56E-09  | (-1.94E-10)            |            |             |            |
|                    | -8.53E-04*                                   | -6.75E-07*  | -3.73E-06*  | -4.47E-07*  | -1.05E-07*             | -7.16E-08* | -4.86E-08* | -2.99E-08*             | -1.59E-08* | -5.60E-09*  | -6.39E-10* |
| 4                  | -1.7353                                      | -1.3219   | -1.0717   | -.9041  | -.7841                 | -.6940     | -.6240     | -.5681                 | -.5224     | -.4845      | -.4526     |
|                    | -5762.7                                      | -7565.0   | -9331.2   | -11061.1  | -12753.9               | -14409.0   | -16025.8   | -17603.4               | -19141.2   | -20638.4    | -22094.5   |
|                    | 1.35E-07                                     | 4.05E-08  | 1.66E-10  | 5.80E-11  | 1.56E-12               | 2.61E-13   | 1.81E-13   | 9.95E-14               | 4.78E-14   | 1.92E-14    | 5.16E-15   |
|                    | 2.8971                                       | 1.4389  | 2.4594  | 1.3526  | .5781                  | .5260      | .8229      | .8671                  | .8670      | .8468       | .7513      |
|                    | 1.01E-03                                     | 1.80E-01  | 8.73E-03  | 2.05E-01  | 2.61E-01               | 2.50E-01   | 2.88E-01   | 2.88E-01               | 2.88E-01   | 2.88E-01    | 2.84E-01   |
|                    | (-1.06E-07)                                  | -2.31E-03   | (-4.15E-08)(-1.33E-05)(-8.92E-07)(-1.98E-07)            | -2.50E-07   | -1.82E-07              | -1.12E-07  | -5.68E-08  | -1.82E-08              |            |             |            |
|                    | -6.56E-03*                                   | -2.17E-03*  | -1.31E-05*  | -1.14E-05*  | -2.11E-06*             | -4.53E-07* | -2.61E-07* | -1.78E-07*             | -1.10E-07* | -5.62E-08*  | -1.97E-08* |
| 5                  | -2.4942                                      | -1.7207   | -1.3196   | -1.0744   | -.9091                 | -.7902     | -.7007     | -.6309                 | -.5751     | -.5295      | -.4916     |
|                    | -4009.3                                      | -5811.5   | -7577.8   | -9307.6   | -11000.4               | -12655.5   | -14272.3   | -15850.0               | -17387.7   | -18884.9    | -20341.0   |
|                    | 2.34E-04                                     | 4.77E-08  | 1.07E-07  | 9.55E-11  | 1.82E-10               | 7.86E-12   | 9.36E-13   | 5.69E-13               | 3.35E-13   | 1.59E-13    | 5.96E-14   |
|                    | 1.6808                                       | 4.8365  | 1.5095  | 3.6226  | 1.4312                 | .7737      | .5022      | .7809                  | .8611      | .8601       | .8176      |
|                    | 1.13E-01                                     | 1.39E-10  | 1.60E-01  | 8.96E-06  | 1.83E-01               | 2.86E-01   | 2.45E-01   | 2.86E-01               | 2.88E-01   | 2.88E-01    | 2.88E-01   |
|                    | -7.87E-01                                    | (-7.29E-22)   | -4.82E-03   | (-2.51E-14)(-3.27E-05)(-5.27E-06)(-6.60E-07)(-7.51E-07) | -5.92E-07              | -3.61E-07  | -1.68E-07  |                        |            |             |            |
|                    | -7.30E-01*                                   | -2.54E-02*  | -4.41E-03*  | -8.79E-05*  | -2.63E-05*             | -7.76E-06* | -1.66E-06* | -8.47E-07*             | -5.77E-07* | -3.52E-07*  | -1.70E-07* |
| 6                  | -4.3747                                      | -2.4461   | -1.7081   | -1.3185   | -1.0779                | -.9147     | -.7969     | -.7079                 | -.6384     | -.5827      | -.5371     |
|                    | -2285.8                                      | -4088.1   | -5854.4   | -7584.2   | -9277.0                | -10932.1   | -12548.9   | -14126.5               | -15664.3   | -17161.5    | -18617.6   |
|                    | 1.24E-02                                     | 3.51E-04  | 2.37E-08  | 2.36E-07  | 1.71E-11               | 4.58E-10   | 3.21E-11   | 3.27E-12               | 1.60E-12   | 9.45E-13    | 4.47E-13   |
|                    | 1.5156                                       | 1.7108  | -4.7547   | 1.5800  | -6.0921                | 1.5117     | .9278      | .5385                  | .7371      | .8428       | .8456      |
|                    | 1.58E-01                                     | 1.06E-01  | 1.10E-19  | 1.40E-01  | 1.60E-29               | 1.59E-01   | 2.86E-01   | 2.53E-01               | 2.83E-01   | 2.88E-01    | 2.88E-01   |
|                    | -1.51E+01                                    | (-1.09E+00)(-2.34E-40)(-8.21E-03)(0.00E+00)(-6.16E-05)(-2.09E-05)(-2.39E-06)(-1.99E-06) | -1.60E-06   | -9.69E-07   |                        |            |            |                        |            |             |            |
|                    | -1.51E+01                                    | -9.82E-01*  | -7.62E-02*  | -7.25E-03*  | -3.77E-04*             | -4.55E-05* | -2.36E-05* | -5.51E-06*             | -2.47E-06* | -1.59E-06*  | -9.47E-07* |
| 7                  | -16.8796                                     | -4.1759   | -2.4033   | -1.6976   | -1.3186                | -1.0824    | -.9212     | -.8043                 | -.7158     | -.6465      | -.5909     |
|                    | -592.4                                       | -2394.7   | -4160.9   | -5890.8   | -7583.6                | -9238.7    | -10855.5   | -12433.1               | -13970.9   | -15468.1    | -16924.2   |
|                    | 1.36E-01                                     | 1.74E-02  | 4.73E-04  | 6.80E-07  | 4.46E-07               | 1.29E-09   | 9.29E-10   | 1.09E-10               | 1.09E-11   | 4.10E-12    | 2.32E-12   |
|                    | 1.4265                                       | 1.5296  | 1.7467  | .0566   | 1.6556                 | .3154      | 1.6018     | 1.0540                 | .6153      | .6963       | .8128      |
|                    | 1.84E-01                                     | 1.54E-01  | 9.73E-02  | 1.23E-01  | 1.20E-01               | 1.96E-01   | 1.34E-01   | 2.72E-01               | 2.67E-01   | 2.79E-01    | 2.87E-01   |
|                    | -3.88E+00                                    | -2.31E+01   | (-1.31E+00)(-8.54E-03)(-1.13E-02)(-1.59E-04)(-8.68E-05) | -6.27E-05   | (-8.61E-06)(-4.78E-06) | -3.76E-06  |            |                        |            |             |            |
|                    | -3.90E+00                                    | -2.32E+01   | -1.12E+00*  | -1.89E+01*  | -9.35E-03*             | -1.20E-03* | -5.47E-05* | -6.00E-05*             | -1.63E-05* | -6.56E-06*  | -3.89E-06* |

Table 14. Radiative transition parameters for  $N_2^+ A^2\Pi_u - X^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . - Continued

| $v'\backslash v''$ | 0         | 1         | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9         | 10        |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 8                  | .4317     | .4765     | .5306     | .5975     | .6821     | .7926     | .9427     | 1.1586    | 1.4949    | 2.0913    | 3.4379    |
|                    | 23163.4   | 20988.5   | 18846.2   | 16736.8   | 14660.3   | 12617.1   | 10607.3   | 8631.2    | 6689.2    | 4781.6    | 2908.7    |
|                    | 6.81E-05  | 1.45E-03  | 1.26E-02  | 5.39E-02  | 1.09E-01  | 6.99E-02  | 9.28E-04  | 1.01E-01  | 2.85E-02  | 9.83E-02  | 4.18E-02  |
|                    | .9328     | .9579     | .9859     | 1.0165    | 1.0499    | 1.0889    | 1.0196    | 1.1519    | 1.2189    | 1.2330    | 1.3389    |
|                    | 2.85E-01  | 2.84E-01  | 2.81E-01  | 2.77E-01  | 2.73E-01  | 2.67E-01  | 2.77E-01  | 2.55E-01  | 2.40E-01  | 2.36E-01  | 2.09E-01  |
|                    | 1.40E+02  | 2.19E+03  | 1.35E+04  | 3.94E+04  | 5.17E+04  | 2.02E+04  | 1.72E+02  | 8.50E+03  | 9.93E+02  | 1.22E+03  | 9.06E+01  |
|                    | 1.42E+02* | 2.22E+03* | 1.36E+04  | 3.97E+04  | 5.18E+04  | 2.00E+04  | 2.01E+02* | 8.52E+03  | 9.63E+02  | 1.23E+03  | 8.83E+01  |
| 9                  | .4033     | .4420     | .4883     | .5444     | .6137     | .7017     | .8169     | .9742     | 1.2015    | 1.5588    | 2.2016    |
|                    | 24796.8   | 22621.9   | 20479.7   | 18370.2   | 16293.8   | 14250.5   | 12240.7   | 10264.6   | 8322.6    | 6415.0    | 4542.2    |
|                    | 1.90E-05  | 4.54E-04  | 4.63E-03  | 2.51E-02  | 7.33E-02  | 1.00E-01  | 3.19E-02  | 1.64E-02  | 1.01E-01  | 5.45E-03  | 1.18E-01  |
|                    | .9172     | .9394     | .9649     | .9932     | 1.0241    | 1.0582    | 1.1019    | 1.1013    | 1.1615    | 1.2623    | 1.2435    |
|                    | 2.86E-01  | 2.85E-01  | 2.83E-01  | 2.80E-01  | 2.76E-01  | 2.72E-01  | 2.64E-01  | 2.64E-01  | 2.53E-01  | 2.29E-01  | 2.34E-01  |
|                    | 4.81E+01  | 8.65E+02  | 6.44E+03  | 2.47E+04  | 4.91E+04  | 4.34E+04  | 8.29E+03  | 2.51E+03  | 7.55E+03  | 1.53E+02  | 1.23E+03  |
|                    | 4.89E+01* | 8.78E+02* | 6.52E+03* | 2.49E+04  | 4.93E+04  | 4.33E+04  | 8.12E+03  | 2.59E+03  | 7.53E+03  | 1.42E+02* | 1.23E+03  |
| 10                 | .3788     | .4128     | .4528     | .5007     | .5587     | .6308     | .7223     | .8426     | 1.0074    | 1.2471    | 1.6272    |
|                    | 26400.3   | 24225.4   | 22083.1   | 19973.7   | 17897.2   | 15853.9   | 13844.1   | 11868.1   | 9926.1    | 8018.5    | 6145.6    |
|                    | 5.52E-06  | 1.43E-04  | 1.65E-03  | 1.06E-02  | 4.03E-02  | 8.48E-02  | 7.80E-02  | 7.56E-03  | 4.04E-02  | 8.49E-02  | 2.21E-04  |
|                    | .9043     | .9234     | .9462     | .9721     | 1.0006    | 1.0318    | 1.0671    | 1.1269    | 1.1178    | 1.1714    | .8923     |
|                    | 2.87E-01  | 2.86E-01  | 2.84E-01  | 2.82E-01  | 2.79E-01  | 2.75E-01  | 2.70E-01  | 2.60E-01  | 2.61E-01  | 2.51E-01  | 2.87E-01  |
|                    | 1.69E+01  | 3.37E+02  | 2.91E+03  | 1.37E+04  | 3.65E+04  | 5.19E+04  | 3.06E+04  | 1.73E+03  | 5.47E+03  | 5.56E+03  | 8.58E+00  |
|                    | 1.72E+01* | 3.43E+02* | 2.95E+03* | 1.38E+04  | 3.68E+04  | 5.21E+04  | 3.04E+04  | 1.64E+03* | 5.56E+03  | 5.52E+03  | 1.36E+01* |
| 11                 | .3575     | .3876     | .4227     | .4641     | .5136     | .5738     | .6486     | .7440     | .8696     | 1.0425    | 1.2955    |
|                    | 27973.7   | 25798.8   | 23656.6   | 21547.1   | 19470.7   | 17427.4   | 15417.6   | 13441.5   | 11499.5   | 9591.9    | 7719.1    |
|                    | 1.68E-06  | 4.62E-05  | 5.82E-04  | 4.28E-03  | 1.96E-02  | 5.51E-02  | 8.53E-02  | 5.02E-02  | 2.24E-06  | 6.15E-02  | 6.01E-02  |
|                    | .8937     | .9097     | .9297     | .9531     | .9794     | 1.0082    | 1.0399    | 1.0774    | .8789     | 1.1290    | 1.1825    |
|                    | 2.87E-01  | 2.87E-01  | 2.86E-01  | 2.84E-01  | 2.82E-01  | 2.78E-01  | 2.74E-01  | 2.69E-01  | 5.09E-03  | 2.59E-01  | 2.48E-01  |
|                    | 6.15E+00  | 1.32E+02  | 1.27E+03  | 7.00E+03  | 2.33E+04  | 4.58E+04  | 4.77E+04  | 1.78E+04  | 1.19E-04  | 7.39E+03  | 3.44E+03  |
|                    | 6.24E+00* | 1.34E+02* | 1.29E+03* | 7.09E+03* | 2.35E+04  | 4.61E+04  | 4.76E+04  | 1.76E+04  | 7.07E+00* | 7.46E+03  | 3.39E+03  |
| 12                 | .3388     | .3657     | .3968     | .4331     | .4759     | .5271     | .5896     | .6673     | .7667     | .8980     | 1.0796    |
|                    | 29517.2   | 27342.3   | 25200.0   | 23090.6   | 21014.1   | 18970.9   | 16961.1   | 14985.0   | 13043.0   | 11135.4   | 9262.5    |
|                    | 5.36E-07  | 1.54E-05  | 2.07E-04  | 1.68E-03  | 8.91E-03  | 3.08E-02  | 6.61E-02  | 7.52E-02  | 2.48E-02  | 6.37E-03  | 7.31E-02  |
|                    | .8851     | .8984     | .9155     | .9363     | .9602     | .9868     | 1.0159    | 1.0484    | 1.0905    | 1.0713    | 1.1389    |
|                    | 2.88E-01  | 2.87E-01  | 2.86E-01  | 2.85E-01  | 2.83E-01  | 2.81E-01  | 2.77E-01  | 2.73E-01  | 2.66E-01  | 2.70E-01  | 2.57E-01  |
|                    | 2.31E+00  | 5.26E+01  | 5.51E+02  | 3.42E+03  | 1.34E+04  | 3.36E+04  | 5.03E+04  | 3.82E+04  | 7.91E+03  | 1.30E+03  | 7.79E+03  |
|                    | 2.34E+00* | 5.33E+01* | 5.59E+02* | 3.46E+03* | 1.36E+04* | 3.39E+04  | 5.05E+04  | 3.81E+04  | 7.73E+03  | 1.37E+03* | 7.81E+03  |
| 13                 | .3223     | .3466     | .3743     | .4064     | .4439     | .4882     | .5413     | .6061     | .6870     | .7906     | .9280     |
|                    | 31030.7   | 28855.8   | 26713.6   | 24604.1   | 22527.6   | 20484.4   | 18474.6   | 16498.5   | 14556.5   | 12648.9   | 10776.0   |
|                    | 1.59E-07  | 5.51E-06  | 7.52E-05  | 6.58E-04  | 5.88E-03  | 1.57E-02  | 4.23E-02  | 7.05E-02  | 5.18E-02  | 7.41E-05  | 2.86E-02  |
|                    | .8780     | .8890     | .9034     | .9215     | .9430     | .9674     | .9943     | 1.0239    | 1.0576    | 1.1133    | 1.0959    |
|                    | 2.88E-01  | 2.87E-01  | 2.87E-01  | 2.86E-01  | 2.85E-01  | 2.83E-01  | 2.80E-01  | 2.76E-01  | 2.72E-01  | 2.62E-01  | 2.65E-01  |
|                    | 8.95E-01  | 2.14E+01  | 2.39E+02  | 1.63E+03  | 7.28E+03  | 2.18E+04  | 4.23E+04  | 4.90E+04  | 2.67E+04  | 2.11E+03  | 3.68E+03  |
|                    | 9.06E-01* | 2.16E+01* | 2.42E+02* | 1.65E+03* | 7.37E+03* | 2.20E+04  | 4.26E+04  | 4.91E+04  | 2.65E+04  | 2.01E+03* | 3.77E+03  |
| 14                 | .3076     | .3296     | .3546     | .3833     | .4165     | .4552     | .5010     | .5561     | .6234     | .7076     | .8157     |
|                    | 32514.3   | 30339.4   | 28197.1   | 26087.7   | 24011.2   | 21968.0   | 19958.1   | 17982.1   | 16040.1   | 14132.5   | 12259.6   |
|                    | 6.20E-08  | 1.90E-06  | 2.79E-05  | 2.59E-04  | 1.66E-03  | 7.52E-03  | 2.41E-02  | 5.19E-02  | 6.74E-02  | 3.79E-02  | 2.83E-04  |
|                    | .8715     | .8810     | .8932     | .9088     | .9278     | .9499     | .9747     | 1.0020    | 1.0322    | 1.0681    | 1.2589    |
|                    | 2.88E-01  | 2.88E-01  | 2.87E-01  | 2.87E-01  | 2.86E-01  | 2.84E-01  | 2.82E-01  | 2.79E-01  | 2.75E-01  | 2.70E-01  | 2.30E-01  |
|                    | 3.58E-01  | 8.88E+00  | 1.05E+02  | 7.65E+02  | 3.79E+03  | 1.30E+04  | 3.08E+04  | 4.76E+04  | 4.28E+04  | 1.58E+04  | 5.58E+01  |
|                    | 3.62E-01* | 9.00E+00* | 1.06E+02* | 7.76E+02* | 3.84E+03* | 1.32E+04* | 3.11E+04  | 4.79E+04  | 4.27E+04  | 1.56E+04  | 4.37E+01* |
| 15                 | .2944     | .3145     | .3373     | .3631     | .3927     | .4270     | .4670     | .5145     | .5716     | .6416     | .7292     |
|                    | 33967.9   | 31793.0   | 29650.8   | 27541.3   | 25464.9   | 23421.6   | 21411.8   | 19435.7   | 17493.7   | 15586.1   | 13713.3   |
|                    | 2.22E-08  | 7.00E-07  | 1.06E-05  | 1.03E-04  | 7.04E-04  | 3.50E-03  | 1.27E-02  | 3.31E-02  | 5.76E-02  | 5.79E-02  | 2.00E-02  |
|                    | .8651     | .8739     | .8844     | .8978     | .9144     | .9342     | .9569     | .9821     | 1.0098    | 1.0408    | 1.0811    |
|                    | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.87E-01  | 2.86E-01  | 2.85E-01  | 2.84E-01  | 2.81E-01  | 2.78E-01  | 2.74E-01  | 2.68E-01  |
|                    | 1.46E-01  | 3.78E+00  | 4.65E+01  | 3.60E+02  | 1.93E+03  | 7.41E+03  | 2.04E+04  | 3.89E+04  | 4.84E+04  | 3.34E+04  | 7.50E+03  |
|                    | 1.48E-01* | 3.82E+00* | 4.71E+01* | 3.65E+02* | 1.96E+03* | 7.51E+03* | 2.06E+04  | 3.92E+04  | 4.85E+04  | 3.32E+04  | 7.32E+03  |

Table 14. Radiative transition parameters for  $N_2^+ A ^2\Pi_u - X ^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . - Continued

| V' \ V''  | 11          | 12          | 13   | 14  | 15          | 16          | 17          | 18          | 19                     | 20          | 21       |
|-----------|-------------|-------------|--|---|-------------|-------------|-------------|-------------|------------------------|-------------|----------|
| 8         | 9.3372      | -13.6752    | -4.0040  | -2.3655   | -1.6891     | -1.3201     | -1.0879     | -.9285      | -.8125                 | -.7244      | -.6553   |
|           | 1071.0      | -731.3      | -2497.5  | -4227.4   | -5920.1     | -7575.3     | -9192.0     | -10769.7    | -12307.5               | -13804.6    | -15260.8 |
| 2.94E-01  | 1.65E-01    | 2.30E-02    | 5.75E-04   | 3.45E-06  | 7.21E-07    | 8.78E-09    | 1.48E-09    | 3.10E-10    | 3.43E-11               | 9.95E-12    |          |
| 1.3683    | 1.4374      | 1.5446      | 1.7912   | .7608   | 1.7437      | .9535       | 1.7167      | 1.1627      | .7175                  | .6642       |          |
| 2.00E-01  | 1.81E-01    | 1.50E-01    | 8.71E-02   | 2.85E-01  | 9.80E-02    | 2.84E-01    | 1.04E-01    | 2.52E-01    | 2.81E-01               | 2.75E-01    |          |
| 2.94E+01  | -8.56E+00   | -3.28E+01   | (-1.34E+00)(-2.35E-01)(-1.22E-02)(-2.23E-03)(-8.15E-05)(-1.49E-04)(-2.89E-05)(-1.08E-05) |   |             |             |             |             |                        |             |          |
| 2.94E+01  | -8.60E+00   | -3.27E+01   | -1.05E+00  | -4.04E-01*  | -8.57E-03*  | -3.08E-03*  | -3.34E-05*  | -1.28E-04*  | -4.33E-05*             | -1.63E-05*  |          |
| 9         | 3.6977      | 11.0844     | -11.5727   | -3.8552   | -2.3328     | -1.6830     | -1.3230     | -1.0945     | -.9369                 | -.8216      | -.7338   |
|           | 2704.4      | 902.2       | -864.1   | -2593.9   | -4286.7     | -5941.9     | -7558.6     | -9136.3     | -10674.0               | -12171.2    | -13627.3 |
| 1.50E-02  | 2.85E-01    | 1.94E-01    | 2.88E-02   | 6.28E-04  | 1.08E-05    | 9.78E-07    | 3.39E-08    | 1.68E-09    | 7.50E-10               | 1.02E-10    |          |
| 1.3833    | 1.3799      | 1.4489      | 1.5608   | 1.8491  | 1.0550      | 1.8577      | 1.2199      | 1.8971      | 1.2600                 | .8320       |          |
| 1.96E-01  | 1.97E-01    | 1.77E-01    | 1.46E-01   | 7.48E-02  | 2.72E-01    | 7.31E-02    | 2.39E-01    | 6.55E-02    | 2.30E-01               | 2.88E-01    |          |
| 2.31E+01  | 1.65E+01    | -1.59E+01   | -4.32E+01  | (-1.12E+00)(-6.82E-01)(-9.15E-03)(-6.00E-03)(-3.55E-05)(-2.89E-04)(-8.64E-05) |             |             |             |             |                        |             |          |
| 2.21E+01  | 1.65E+01    | -1.60E+01   | -4.31E+01  | -7.33E-01*  | -7.59E-01*  | -3.89E-03*  | -6.44E-03*  | -6.58E-08*  | -2.27E-04*             | -1.04E-04*  |          |
| 10        | 2.3213      | 3.9911      | 13.5258  | -10.0960  | -3.7268     | -2.3050     | -1.6792     | -1.3275     | -1.1025                | -.9463      | -.8317   |
|           | 4307.8      | 2505.6      | 739.3  | -990.5  | -2683.3     | -4338.4     | -5955.2     | -7532.8     | -9070.6                | -10567.8    | -12023.9 |
| 1.24E-01  | 2.27E-03    | 2.70E-01    | 2.20E-01   | 3.44E-02  | 6.06E-04    | 2.63E-05    | 1.06E-06    | 9.59E-08    | 1.01E-09               | 1.53E-09    |          |
| 1.2535    | 1.5362      | 1.3923      | 1.4609   | 1.5785  | 1.9293      | 1.2249      | 2.0287      | 1.3849      | 2.3294                 | 1.3510      |          |
| 2.31E-01  | 1.53E-01    | 1.94E-01    | 1.74E-01   | 1.41E-01  | 5.98E-02    | 2.38E-01    | 4.41E-02    | 1.96E-01    | 1.50E-02               | 2.05E-01    |          |
| 1.07E+03  | ( 1.68E+00) | 8.29E+00    | -2.63E+01  | -5.33E+01   | (-7.16E-01) | -1.28E+00   | (-3.59E-03) | -1.11E-02   | (-1.08E-06)(-4.54E-04) |             |          |
| 1.07E+03  | 1.47E+00*   | 8.27E+00    | -2.64E+01  | -5.30E+01   | -2.82E-01*  | -1.27E+00*  | -2.75E-05*  | -1.10E-02*  | -1.15E-04*             | -3.24E-04*  |          |
| 11        | 1.7003      | 2.4515      | 4.3238   | 17.1539   | -9.0103     | -3.6167     | -2.2822     | -1.6780     | -1.3338                | -1.1118     | -.9569   |
|           | 5881.3      | 4079.1      | 2312.8   | 583.0   | -1109.8     | -2765.0     | -4381.7     | -5959.4     | -7497.2                | -8994.3     | -10450.5 |
| 8.46E-03  | 1.17E-01    | 3.29E-04    | 2.52E-01   | 2.45E-01  | 3.93E-02    | 4.99E-04    | 5.37E-05    | 8.16E-07    | 2.16E-07               | 8.16E-12    |          |
| 1.1637    | 1.2636      | .6776       | 1.4058   | 1.4736  | 1.5980      | 2.0524      | 1.3423      | 2.3559      | 1.5144                 | 14.1990     |          |
| 2.52E-01  | 2.29E-01    | 2.77E-01    | 1.90E-01   | 1.70E-01  | 1.35E-01    | 4.09E-02    | 2.08E-01    | 1.35E-02    | 1.59E-01               | 0.00E+00    |          |
| 2.22E+02  | 8.42E+02    | ( 6.32E-01) | 3.65E+00   | -3.94E+01   | -6.17E+01   | (-2.85E-01) | -1.98E+00   | (-2.53E-04) | -1.60E-02              | ( 0.00E+00) |          |
| 2.35E+02* | 8.39E+02    | 1.45E+00*   | 3.64E+00   | -3.96E+01   | -6.12E+01   | -9.33E-04*  | -1.89E+00*  | -1.46E-02*  | -1.51E-02*             | -7.83E-04*  |          |
| 12        | 1.3468      | 1.7786      | 2.5932   | 4.7027  | 23.0606     | -8.1867     | -3.5233     | -2.2645     | -1.6796                | -1.3421     | -1.1227  |
|           | 7424.8      | 5622.5      | 3856.3   | 2126.4  | 433.6       | -1221.5     | -2838.3     | -4415.9     | -5953.7                | -7450.9     | -8907.0  |
| 3.51E+02  | 2.40E-02    | 1.03E-01    | 5.44E-03   | 2.34E-01  | 2.68E-01    | 4.32E-02    | 3.22E-04    | 9.50E-05    | 2.73E-07               | 3.96E-07    |          |
| 1.1960    | 1.1923      | 1.2739      | 1.1564   | 1.4203  | 1.4870      | 1.6196      | 2.2759      | 1.4344      | 3.4458                 | 1.6373      |          |
| 2.45E-01  | 2.46E-01    | 2.26E-01    | 2.54E-01   | 1.86E-01  | 1.67E-01    | 1.29E-01    | 1.85E-02    | 1.82E-01    | 3.23E-05               | 1.25E-01    |          |
| 1.75E+03  | 5.22E+02    | 6.09E+02    | 6.83E+00   | 1.33E+00  | -5.48E+01   | -6.70E+01   | (-3.85E-02) | -2.68E+00   | (-4.77E-10)(-1.76E-02) |             |          |
| 1.70E+03  | 5.38E+02    | 6.04E+02    | 7.49E+00*  | 1.33E+00  | -5.51E+01   | -6.61E+01   | -4.21E-01*  | -2.50E+00*  | -8.45E-02*             | -1.52E-02*  |          |
| 13        | 1.1188      | 1.4013      | 1.8623   | 2.7473  | 5.1357      | 34.2438     | -7.5486     | -3.4454     | -2.2522                | -1.6843     | -1.3525  |
|           | 8938.3      | 7136.1      | 5369.8   | 3640.0  | 1947.2      | 292.0       | 1324.7      | 2902.4      | -4440.2                | -5937.3     | -7393.5  |
| 7.35E-02  | 1.55E-02    | 4.11E-02    | 8.43E-02   | 1.42E-02  | 2.18E-01    | 2.88E-01    | 4.54E-02    | 1.26E-04    | 1.49E-04               | 3.68E-08    |          |
| 1.1485    | 1.2159      | 1.2075      | 1.2849   | 1.2207  | 1.4361      | 1.5011      | 1.6441      | 2.8493      | 1.5149                 | -4.9646     |          |
| 2.55E-01  | 2.40E-01    | 2.42E-01    | 2.23E-01   | 2.39E-01  | 1.81E-01    | 1.62E-01    | 1.23E-01    | 1.31E-03    | 1.59E-01               | 4.33E-21    |          |
| 6.93E+03  | 6.61E+02    | 7.58E+02    | 4.10E+02   | 1.21E+01  | 3.62E-01    | -7.17E+01   | -6.80E+01   | (-7.60E-05) | -3.17E+00              | (-1.13E-42) |          |
| 6.92E+03  | 6.34E+02    | 7.72E+02    | 4.05E+02   | 1.27E+01  | 3.61E-01    | -7.20E+01   | -6.66E+01   | -2.24E+00*  | -2.90E+00*             | -2.64E-01*  |          |
| 14        | .9595       | 1.1601      | 1.4591   | 1.9518  | 2.9148      | 5.6319      | 62.9628     | -7.0481     | -3.3823                | -2.2453     | -1.6921  |
|           | 10421.9     | 8619.6      | 6853.3   | 5123.5  | 3430.7      | 1775.6      | 158.8       | -1418.8     | -2956.6                | -4453.8     | -5909.9  |
| 5.63E-02  | 6.48E-02    | 5.91E-03    | 5.59E-02   | 6.55E-02  | 2.38E-02    | 2.06E-01    | 3.07E-01    | 4.57E-02    | 4.33E-06               | 2.06E-04    |          |
| 1.1093    | 1.1583      | 1.2597      | 1.2189   | 1.2966  | 1.2475      | 1.4529      | 1.5160      | 1.6723      | 9.0788                 | 1.5924      |          |
| 2.63E-01  | 2.53E-01    | 2.30E-01    | 2.40E-01   | 2.20E-01  | 2.33E-01    | 1.76E-01    | 1.58E-01    | 1.16E-01    | 5.75E-41               | 1.37E-01    |          |
| 5.75E+03  | 5.40E+03    | 1.34E+02    | 8.74E+02   | 2.60E+02  | 1.46E+01    | 5.19E-02    | -8.89E+01   | -6.40E+01   | ( 0.00E+00)(-3.23E+00) |             |          |
| 5.84E+03  | 5.36E+03    | 1.23E+02*   | 8.85E+02   | 2.55E+02  | 1.51E+01    | 5.18E-02    | -8.94E+01   | -6.19E+01   | -6.14E+00*             | -2.85E+00*  |          |
| 15        | .8421       | .9927       | 1.2038   | 1.5204  | 2.0473      | 3.0967      | 6.2017      | 287.2655    | -6.6535                | -3.3332     | -2.2440  |
|           | 11875.5     | 10073.3     | 8307.0   | 6577.2  | 4884.4      | 3229.2      | 1612.5      | 34.8        | -1503.0                | -3000.1     | -4456.3  |
| 2.17E-03  | 4.86E-02    | 5.09E-02    | 2.28E-05   | 6.62E-02  | 4.86E-02    | 3.26E-02    | 1.98E-01    | 3.24E-01    | 4.38E-02               | 8.73E-05    |          |
| 1.0341    | 1.1200      | 1.1688      | 2.1459   | 1.2288  | 1.3095      | 1.2619      | 1.4708      | 1.5317      | 1.7056                 | -.1720      |          |
| 2.75E-01  | 2.61E-01    | 2.51E-01    | 2.98E-02   | 2.37E-01  | 2.17E-01    | 2.29E-01    | 1.71E-01    | 1.54E-01    | 1.07E-01               | 7.03E-02    |          |
| 5.59E+02  | 6.85E+03    | 3.73E+03    | ( 1.17E-02)  | 8.79E+02  | 1.56E+02    | 1.45E+01    | 4.95E-04    | -1.05E+02   | -5.50E+01              | (-1.55E-01) |          |
| 6.13E+02* | 6.91E+03    | 3.68E+03    | 1.71E-01*  | 8.86E+02  | 1.52E+02    | 1.49E+01    | 4.94E-04    | -1.06E+02   | -5.22E+01              | -1.25E+01*  |          |

Table 14. Radiative transition parameters for  $N_2^+ A^2\Pi_u - X^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \setminus V''$ | 0         | 1         | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9        | 10      |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|---------|
| 16                 | .2826     | .3011     | .3218     | .3452     | .3719     | .4025     | .4379     | .4794     | .5286     | .5879    | .6606   |
|                    | 35391.7   | 33216.8   | 31074.5   | 28965.1   | 26888.6   | 24845.3   | 22835.5   | 20859.5   | 18917.5   | 17009.9  | 15137.0 |
| 8.12E-09           | 2.65E-07  | 4.16E-06  | 4.18E-05  | 3.00E-04  | 1.60E-03  | 6.43E-03  | 1.92E-02  | 4.12E-02  | 5.83E-02  | 4.44E-02 |         |
|                    | .8578     | .8669     | .8766     | .8883     | .9028     | .9204     | .9409     | .9641     | .9897     | 1.0179   | 1.0501  |
| 2.88E-01           | 2.88E-01  | 2.88E-01  | 2.87E-01  | 2.87E-01  | 2.86E-01  | 2.85E-01  | 2.83E-01  | 2.81E-01  | 2.77E-01  | 2.73E-01 |         |
| 6.05E-02           | 1.63E+00  | 2.09E+01  | 1.70E+02  | 9.73E+02  | 4.07E+03  | 1.26E+04  | 2.83E+04  | 4.44E+04  | 4.47E+04  | 2.32E+04 |         |
| 6.11E-02*          | 1.65E+00* | 2.12E+01* | 1.73E+02* | 9.87E+02* | 4.13E+03* | 1.27E+04* | 2.86E+04  | 4.47E+04  | 4.47E+04  | 2.30E+04 |         |
| 17                 | .2718     | .2889     | .3080     | .3294     | .3536     | .3811     | .4127     | .4494     | .4923     | .5434    | .6049   |
|                    | 36785.6   | 34610.6   | 32468.4   | 30358.9   | 28282.5   | 26239.2   | 24229.4   | 22253.3   | 20311.4   | 18403.7  | 16530.9 |
| 2.99E-09           | 1.02E-07  | 1.66E-06  | 1.72E-05  | 1.29E-04  | 7.28E-04  | 3.16E-03  | 1.05E-02  | 2.63E-02  | 4.70E-02  | 5.40E-02 |         |
|                    | .8490     | .8595     | .8691     | .8797     | .8925     | .9081     | .9266     | .9478     | .9714     | .9974    | 1.0262  |
| 2.88E-01           | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.87E-01  | 2.87E-01  | 2.86E-01  | 2.84E-01  | 2.82E-01  | 2.80E-01  | 2.76E-01 |         |
| 2.50E-02           | 7.09E-01  | 9.51E+00  | 8.09E+01  | 4.88E+02  | 2.19E+03  | 7.44E+03  | 1.90E+04  | 3.56E+04  | 4.64E+04  | 3.77E+04 |         |
| 2.53E-02*          | 7.17E-01* | 9.63E+00* | 8.20E+01* | 4.95E+02* | 2.22E+03* | 7.54E+03* | 1.92E+04  | 3.59E+04  | 4.66E+04  | 3.76E+04 |         |
| 18                 | .2621     | .2780     | .2956     | .3152     | .3373     | .3623     | .3907     | .4234     | .4614     | .5059    | .5588   |
|                    | 38149.6   | 35974.7   | 33832.5   | 31723.0   | 29646.5   | 27603.3   | 25593.5   | 23617.4   | 21675.4   | 19767.8  | 17895.0 |
| 1.09E-09           | 3.93E-08  | 6.67E-07  | 7.21E-06  | 5.60E-05  | 3.31E-04  | 1.53E-03  | 5.56E-03  | 1.56E-02  | 3.31E-02  | 4.95E-02 |         |
|                    | .8375     | .8506     | .8612     | .8716     | .8833     | .8971     | .9137     | .9330     | .9548     | .9788    | 1.0053  |
| 2.88E-01           | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.87E-01  | 2.86E-01  | 2.85E-01  | 2.84E-01  | 2.82E-01  | 2.79E-01 |         |
| 1.02E-02           | 3.07E-01  | 4.34E+00  | 3.86E+01  | 2.44E+02  | 1.16E+03  | 4.27E+03  | 1.21E+04  | 2.60E+04  | 4.11E+04  | 4.47E+04 |         |
| 1.03E-02*          | 3.11E-01* | 4.39E+00* | 3.91E+01* | 2.48E+02* | 1.18E+03* | 4.33E+03* | 1.22E+04* | 2.63E+04  | 4.14E+04  | 4.48E+04 |         |
| 19                 | .2533     | .2680     | .2844     | .3025     | .3228     | .3456     | .3714     | .4008     | .4346     | .4739    | .5200   |
|                    | 39484.0   | 37309.0   | 35166.8   | 33057.3   | 30980.9   | 28937.6   | 26927.8   | 24951.8   | 23009.8   | 21102.2  | 19229.3 |
| 3.85E-10           | 1.50E-08  | 2.69E-07  | 3.03E-06  | 2.45E-05  | 1.51E-04  | 7.37E-04  | 2.87E-03  | 8.86E-03  | 2.13E-02  | 3.85E-02 |         |
|                    | .8211     | .8391     | .8521     | .8633     | .8745     | .8872     | .9021     | .9196     | .9396     | .9619    | .9864   |
| 2.88E-01           | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.87E-01  | 2.87E-01  | 2.86E-01  | 2.85E-01  | 2.83E-01  | 2.81E-01 |         |
| 3.97E-03           | 1.31E-01  | 1.96E+00  | 1.84E+01  | 1.22E+02  | 6.14E+02  | 2.40E+03  | 7.39E+03  | 1.77E+04  | 3.26E+04  | 4.38E+04 |         |
| 4.06E-03*          | 1.33E-01* | 1.99E+00* | 1.86E+01* | 1.24E+02* | 6.22E+02* | 2.44E+03* | 7.49E+03* | 1.80E+04* | 3.28E+04  | 4.40E+04 |         |
| 20                 | .2452     | .2590     | .2742     | .2910     | .3097     | .3307     | .3542     | .3809     | .4113     | .4463    | .4870   |
|                    | 40788.6   | 38613.7   | 36471.5   | 34362.0   | 32285.6   | 30242.3   | 28232.5   | 26256.4   | 24314.4   | 22406.8  | 20534.0 |
| 1.26E-10           | 5.51E-09  | 1.07E-07  | 1.27E-06  | 1.07E-05  | 6.92E-05  | 3.53E-04  | 1.45E-03  | 4.85E-03  | 1.29E-02  | 2.69E-02 |         |
|                    | .7957     | .8231     | .8407     | .8539     | .8657     | .8778     | .8915     | .9074     | .9258     | .9464    | .9692   |
| 2.87E-01           | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.87E-01  | 2.87E-01  | 2.86E-01  | 2.84E-01  | 2.83E-01 |         |
| 1.43E-03           | 5.32E-02  | 8.69E-01  | 8.67E+00  | 6.07E+01  | 3.21E+02  | 1.33E+03  | 4.39E+03  | 1.15E+04  | 2.38E+04  | 3.77E+04 |         |
| 1.47E-03*          | 5.43E-02* | 8.83E-01* | 8.79E+00* | 6.15E+01* | 3.25E+02* | 1.35E+03* | 4.45E+03* | 1.17E+04* | 2.41E+04  | 3.80E+04 |         |
| 21                 | .2377     | .2507     | .2649     | .2806     | .2980     | .3173     | .3389     | .3632     | .3908     | .4223    | .4585   |
|                    | 42063.8   | 39888.8   | 37746.6   | 35637.2   | 33560.7   | 31517.4   | 29507.6   | 27531.6   | 25589.6   | 23682.0  | 21809.1 |
| 3.55E-11           | 1.88E-09  | 4.08E-08  | 5.25E-07  | 4.68E-06  | 3.16E-05  | 1.69E-04  | 7.31E-04  | 2.59E-03  | 7.52E-03  | 1.75E-02 |         |
|                    | .7501     | .7983     | .8249     | .8424     | .8559     | .8684     | .8815     | .8962     | .9131     | .9321    | .9533   |
| 2.84E-01           | 2.87E-01  | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.88E-01  | 2.87E-01  | 2.86E-01  | 2.85E-01  | 2.84E-01 |         |
| 4.32E-04           | 1.99E-02  | 3.68E-01  | 3.99E+00  | 2.97E+01  | 1.66E+02  | 7.26E+02  | 2.55E+03  | 7.23E+03  | 1.65E+04  | 2.96E+04 |         |
| 4.61E-04*          | 2.06E-02* | 3.76E-01* | 4.05E+00* | 3.02E+01* | 1.68E+02* | 7.36E+02* | 2.59E+03  | 7.33E+03* | 1.67E+04* | 2.99E+04 |         |

Table 14. Radiative transition parameters for  $N_2^+ A^2\Pi_u - X^2\Sigma^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| $V' \backslash V''$ | 11          | 12          | 13          | 14          | 15        | 16        | 17          | 18          | 19        | 20        | 21       |
|---------------------|-------------|-------------|-------------|-------------|-----------|-----------|-------------|-------------|-----------|-----------|----------|
| 16                  | .7519       | .8698       | 1.0277      | 1.2499      | 1.5853    | 2.1492    | 3.2936      | 6.8561      | -126.2308 | -6.3436   | -3.2976  |
|                     | 13299.2     | 11497.0     | 9730.7      | 8000.9      | 6308.1    | 4653.0    | 3036.2      | 1458.6      | -79.2     | -1576.4   | -3032.5  |
| 7.22E-03            | 1.01E-02    | 5.50E-02    | 3.56E-02    | 2.13E-03    | 7.16E-02  | 3.47E-02  | 3.92E-02    | 1.95E-01    | 3.38E-01  | 3.94E-02  |          |
| 1.1016              | 1.0753      | 1.1298      | 1.1806      | 1.1035      | 1.2379    | 1.3238    | 1.2695      | 1.4896      | 1.5483    | 1.7465    |          |
| 2.64E-01            | 2.69E-01    | 2.59E-01    | 2.48E-01    | 2.64E-01    | 2.35E-01  | 2.13E-01  | 2.27E-01    | 1.66E-01    | 1.49E-01  | 9.73E-02  |          |
| 2.40E+03            | 2.25E+03    | 6.89E+03    | 2.28E+03    | ( 7.56E+01) | 8.07E+02  | 8.91E+01  | 1.27E+01    | -1.08E-02   | -1.19E+02 | -4.22E+01 |          |
| 2.30E+03*           | 2.34E+03    | 6.91E+03    | 2.24E+03    | 8.53E+01*   | 8.10E+02  | 8.66E+01  | 1.30E+01    | -1.08E-02   | -1.20E+02 | -3.87E+01 |          |
| 17                  | .6806       | .7757       | .8989       | 1.0644      | 1.2984    | 1.6538    | 2.2573      | 3.5058      | 7.6065    | -54.7909  | -6.1027  |
|                     | 14693.1     | 12890.9     | 11124.6     | 9394.8      | 7702.0    | 6046.9    | 4430.1      | 2852.4      | 1314.7    | -182.5    | -1638.6  |
| 2.97E-02            | 8.71E-04    | 2.05E-02    | 5.53E-02    | 2.19E-02    | 7.93E-03  | 7.27E-02  | 2.40E-02    | 4.33E-02    | 1.97E-01  | 3.50E-01  |          |
| 1.0605              | 1.1686      | 1.0921      | 1.1394      | 1.1950      | 1.1582    | 1.2465    | 1.3396      | 1.2719      | 1.5089    | 1.5659    |          |
| 2.71E-01            | 2.51E-01    | 2.66E-01    | 2.57E-01    | 2.45E-01    | 2.53E-01  | 2.33E-01  | 2.08E-01    | 2.26E-01    | 1.60E-01  | 1.44E-01  |          |
| 1.41E+04            | ( 2.38E+02) | 4.05E+03    | 6.14E+03    | 1.22E+03    | 2.28E+02  | 6.95E+02  | 4.90E+01    | 1.02E+01    | -1.25E-01 | -1.30E+02 |          |
| 1.38E+04            | 2.08E+02*   | 4.15E+03    | 6.13E+03    | 1.18E+03    | 2.41E+02* | 6.95E+02  | 4.72E+01    | 1.04E+01    | -1.25E-01 | -1.31E+02 |          |
| 18                  | .6228       | .7015       | .8007       | .9295       | 1.1030    | 1.3494    | 1.7259      | 2.3716      | 3.7331    | 8.4634    | -36.4224 |
|                     | 16057.2     | 14255.0     | 12488.7     | 10758.9     | 9066.1    | 7410.9    | 5794.2      | 4216.5      | 2678.7    | 1181.6    | -274.6   |
| 4.57E-02            | 1.67E-02    | 4.72E-04    | 3.03E-02    | 5.06E-02    | 1.13E-02  | 1.53E-02  | 7.07E-02    | 1.63E-02    | 4.46E-02  | 2.06E-01  |          |
| 1.0349              | 1.0730      | .9632       | 1.1041      | 1.1491      | 1.2146    | 1.1796    | 1.2547      | 1.3571      | 1.2688    | 1.5283    |          |
| 2.75E-01            | 2.69E-01    | 2.83E-01    | 2.64E-01    | 2.55E-01    | 2.41E-01  | 2.49E-01  | 2.31E-01    | 2.04E-01    | 2.27E-01  | 1.55E-01  |          |
| 2.90E+04            | 7.11E+03    | ( 1.49E+02) | 5.33E+03    | 4.98E+03    | 5.41E+02  | 3.72E+02  | 5.72E+02    | 2.62E+01    | 7.70E+00  | -4.14E+01 |          |
| 2.88E+04            | 6.94E+03    | 1.83E+02*   | 5.41E+03    | 4.95E+03    | 5.17E+02  | 3.86E+02  | 5.71E+02    | 2.50E+01    | 7.81E+00  | -4.17E-01 |          |
| 19                  | .5750       | .6415       | .7234       | .8269       | .9615     | 1.1435    | 1.4028      | 1.8015      | 2.4919    | 3.9747    | 9.4359   |
|                     | 17391.5     | 15589.3     | 13823.0     | 12093.2     | 10400.4   | 8745.3    | 7128.5      | 5550.8      | 4013.1    | 2515.9    | 1059.8   |
| 4.84E-02            | 3.52E-02    | 7.10E-03    | 4.42E-03    | 3.75E-02    | 4.29E-02  | 4.46E-03  | 2.25E-02    | 6.66E-02    | 1.09E-02  | 4.34E-02  |          |
| 1.0133              | 1.0441      | 1.0906      | 1.0541      | 1.1145      | 1.1591    | 1.2476    | 1.1932      | 1.2625      | 1.3757    | 1.2595    |          |
| 2.78E-01            | 2.74E-01    | 2.66E-01    | 2.72E-01    | 2.62E-01    | 2.53E-01  | 2.33E-01  | 2.44E-01    | 2.29E-01    | 1.90E-01  | 2.30E-01  |          |
| 3.98E+04            | 2.02E+04    | 2.70E+03    | 1.17E+03    | 5.87E+03    | 3.73E+03  | 1.77E+02  | 4.70E+02    | 4.57E+02    | 1.39E+01  | 5.52E+00  |          |
| 3.98E+04            | 2.00E+04    | 2.58E+03*   | 1.25E+03*   | 5.92E+03    | 3.69E+03  | 1.65E+02* | 4.83E+02    | 4.55E+02    | 1.31E+01  | 5.60E+00  |          |
| 20                  | .5349       | .5919       | .6610       | .7464       | .8543     | .9950     | 1.1858      | 1.4587      | 1.8805    | 2.6174    | 4.2293   |
|                     | 18696.2     | 16894.0     | 15127.7     | 13397.9     | 11705.1   | 10049.9   | 8433.2      | 6855.5      | 5317.8    | 3820.6    | 2364.5   |
| 4.18E-02            | 4.39E-02    | 2.43E-02    | 1.62E-03    | 1.07E-02    | 4.12E-02  | 3.40E-02  | 9.43E-04    | 2.87E-02    | 6.16E-02  | 7.49E-03  |          |
| .9941               | 1.0216      | 1.0541      | 1.1290      | 1.0767      | 1.1243    | 1.1698    | 1.3366      | 1.2036      | 1.2698    | 1.3946    |          |
| 2.80E-01            | 2.77E-01    | 2.72E-01    | 2.59E-01    | 2.69E-01    | 2.60E-01  | 2.51E-01  | 2.09E-01    | 2.43E-01    | 2.27E-01  | 1.93E-01  |          |
| 4.34E+04            | 3.29E+04    | 1.26E+04    | ( 5.29E+02) | 2.51E+03    | 5.74E+03  | 2.60E+03  | ( 2.69E+01) | 5.17E+02    | 3.58E+02  | 7.47E+00  |          |
| 4.35E+04            | 3.27E+04    | 1.24E+04    | 4.81E+02*   | 2.59E+03    | 5.77E+03  | 2.56E+03  | 2.30E+01*   | 5.27E+02    | 3.56E+02  | 6.92E+00* |          |
| 21                  | .5007       | .5504       | .6097       | .6815       | .7704     | .8830     | 1.0300      | 1.2299      | 1.5168    | 1.9624    | 2.7476   |
|                     | 19971.3     | 18169.1     | 16402.8     | 14673.0     | 12980.2   | 11325.1   | 9708.3      | 8130.6      | 6592.9    | 5095.7    | 3639.6   |
| 3.17E-02            | 4.24E-02    | 3.71E-02    | 1.47E-02    | 6.08E-07    | 1.74E-02  | 4.17E-02  | 2.53E-02    | 7.32E-07    | 3.34E-02  | 5.62E-02  |          |
| .9765               | 1.0019      | 1.0301      | 1.0655      | -1.9170     | 1.0906    | 1.1337    | 1.1814      | -4.2799     | 1.2124    | 1.2764    |          |
| 2.82E-01            | 2.79E-01    | 2.76E-01    | 2.70E-01    | 9.34E-06    | 2.66E-01  | 2.58E-01  | 2.48E-01    | 1.07E-16    | 2.41E-01  | 2.25E-01  |          |
| 4.07E+04            | 4.02E+04    | 2.52E+04    | 6.89E+03    | ( 2.35E-10) | 3.64E+03  | 5.16E+03  | 1.70E+03    | ( 4.89E-33) | 5.20E+02  | 2.79E+02  |          |
| 4.09E+04            | 4.02E+04    | 2.50E+04    | 6.71E+03    | 5.72E+00*   | 3.72E+03  | 5.17E+03  | 1.67E+03    | 2.06E+00*   | 5.28E+02  | 2.76E+02  |          |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 15. Radiative transition parameters for  $N_2^+ B^2\Sigma_u^+ - X^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$

| $v'\backslash v''$ | 0           | 1           | 2           | 3         | 4         | 5         | 6         | 7         | 8         | 9         | 10      |
|--------------------|-------------|-------------|-------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---------|
| 0                  | .3912       | .4275       | .4706       | .5225     | .5861     | .6659     | .7687     | .9064     | 1.1000    | 1.3922    | 1.8832  |
|                    | 25564.7     | 23389.8     | 21247.6     | 19138.1   | 17061.7   | 15018.4   | 13008.6   | 11032.5   | 9090.5    | 7182.9    | 5310.1  |
| 6.63E-01           | 2.53E-01    | 6.58E-02    | 1.45E-02    | 2.98E-03  | 6.04E-04  | 1.26E-04  | 2.78E-05  | 6.71E-06  | 1.82E-06  | 5.67E-07  |         |
| 1.0995             | 1.0508      | 1.0113      | .9762       | .9450     | .9179     | .8953     | .8778     | .8659     | .8598     | .8593     |         |
| 7.13E-01           | 7.52E-01    | 7.81E-01    | 8.07E-01    | 8.28E-01  | 8.46E-01  | 8.61E-01  | 8.71E-01  | 8.79E-01  | 8.82E-01  | 8.83E-01  |         |
| 1.14E+07           | 3.71E+06    | 7.81E+05    | 1.34E+05    | 2.06E+04  | 2.97E+03  | 4.15E+02  | 5.74E+01  | 7.89E+00  | 1.06E+00  | 1.34E+01  |         |
| 1.14E+07           | 3.71E+06    | 7.84E+05    | 1.35E+05    | 2.07E+04* | 2.99E+03* | 4.18E+02* | 5.77E+01* | 7.93E+00* | 1.07E+00* | 1.34E-01* |         |
| 1                  | .3580       | .3882       | .4234       | .4649     | .5146     | .5750     | .6502     | .7460     | .8724     | 1.0466    | 1.3018  |
|                    | 27936.3     | 25761.3     | 23619.1     | 21509.6   | 19433.2   | 17389.9   | 15380.1   | 13404.0   | 11462.0   | 9554.4    | 7681.6  |
| 2.92E-01           | 2.37E-01    | 2.87E-01    | 1.29E-01    | 4.07E-02  | 1.10E-02  | 2.76E-03  | 6.91E-04  | 1.79E-04  | 4.99E-05  | 1.54E-05  |         |
| 1.1527             | 1.1115      | 1.0567      | 1.0169      | .9818     | .9508     | .9238     | .9012     | .8836     | .8716     | .8653     |         |
| 6.68E-01           | 7.03E-01    | 7.47E-01    | 7.77E-01    | 8.03E-01  | 8.24E-01  | 8.42E-01  | 8.57E-01  | 8.68E-01  | 8.75E-01  | 8.79E-01  |         |
| 5.75E+06           | 4.06E+06    | 4.27E+06    | 1.57E+06    | 3.90E+05  | 7.94E+04  | 1.45E+04  | 2.48E+03  | 4.12E+02  | 6.76E+01  | 1.09E+01  |         |
| 5.76E+06           | 4.03E+06    | 4.28E+06    | 1.57E+06    | 3.92E+05  | 7.99E+04  | 1.46E+04* | 2.49E+03* | 4.14E+02* | 6.79E+01* | 1.10E+01* |         |
| 2                  | .3305       | .3561       | .3855       | .4197     | .4597     | .5074     | .5650     | .6360     | .7257     | .8423     | 1.0000  |
|                    | 30254.5     | 28079.5     | 25937.3     | 23827.9   | 21751.4   | 19708.1   | 17698.3   | 15722.3   | 13780.3   | 11872.6   | 9999.8  |
| 4.31E-02           | 4.02E-01    | 5.72E-02    | 2.30E-01    | 1.63E-01  | 6.97E-02  | 2.37E-02  | 7.23E-03  | 2.13E-03  | 6.39E-04  | 2.03E-04  |         |
| 1.2191             | 1.1609      | 1.1357      | 1.0628      | 1.0224    | .9873     | .9565     | .9297     | .9072     | .8897     | .8776     |         |
| 6.08E-01           | 6.61E-01    | 6.83E-01    | 7.42E-01    | 7.73E-01  | 7.99E-01  | 8.20E-01  | 8.38E-01  | 8.53E-01  | 8.64E-01  | 8.72E-01  |         |
| 8.94E+05           | 7.88E+06    | 9.43E+05    | 3.48E+06    | 2.04E+06  | 6.90E+05  | 1.79E+05  | 4.00E+04  | 8.22E+03  | 1.62E+03  | 3.12E+02  |         |
| 9.02E+05           | 7.88E+06    | 9.27E+05    | 3.47E+06    | 2.04E+06  | 6.93E+05  | 1.80E+05  | 4.02E+04* | 8.27E+03* | 1.63E+03* | 3.14E+02* |         |
| 3                  | .3076       | .3296       | .3546       | .3833     | .4165     | .4552     | .5011     | .5561     | .6234     | .7076     | .8157   |
|                    | 32514.1     | 30339.2     | 28197.0     | 26087.5   | 24011.0   | 21967.8   | 19958.0   | 17981.9   | 16039.9   | 14132.3   | 12259.4 |
| 2.14E-03           | 1.01E-01    | 4.19E-01    | 3.52E+03    | 1.53E-01  | 1.67E-01  | 9.32E-02  | 3.89E-02  | 1.41E-02  | 4.84E-03  | 1.66E-03  |         |
| 1.3210             | 1.2284      | 1.1702      | 1.2654      | 1.0689    | 1.0279    | .9925     | .9620     | .9355     | .9132     | .8958     |         |
| 5.09E-01           | 6.00E-01    | 6.53E-01    | 5.64E-01    | 7.37E-01  | 7.69E-01  | 7.95E-01  | 8.17E-01  | 8.35E-01  | 8.49E-01  | 8.60E-01  |         |
| 3.86E+04           | 2.06E+06    | 8.10E+06    | 4.03E+04    | 2.33E+06  | 2.13E+06  | 9.49E+05  | 3.06E+05  | 8.22E+04  | 1.99E+04  | 4.58E+03  |         |
| 3.98E+04*          | 2.08E+06    | 8.09E+06    | 3.77E+04*   | 2.32E+06  | 2.13E+06  | 9.52E+05  | 3.07E+05  | 8.26E+04  | 2.01E+04* | 4.61E+03* |         |
| 4                  | .2881       | .3074       | .3290       | .3536     | .3816     | .4139     | .4514     | .4956     | .5484     | .6125     | .6919   |
|                    | 34708.5     | 32533.6     | 30391.3     | 28281.9   | 26205.4   | 24162.2   | 22152.4   | 20176.3   | 18234.3   | 16326.7   | 14453.8 |
| 7.48E-06           | 6.26E-03    | 1.60E-01    | 3.95E-01    | 4.21E-03  | 8.62E-02  | 1.50E-01  | 1.07E-01  | 5.36E-02  | 2.28E-02  | 8.97E-03  |         |
| 1.8293             | 1.3401      | 1.2386      | 1.1808      | .9370     | 1.0751    | 1.0335    | .9975     | .9673     | .9411     | .9192     |         |
| -1.32E-01          | 4.89E-01    | 5.90E-01    | 6.43E-01    | 8.34E-01  | 7.33E-01  | 7.65E-01  | 7.91E-01  | 8.13E-01  | 8.31E-01  | 8.45E-01  |         |
| ( 1.10E+01)        | 1.04E+05    | 3.17E+06    | 7.50E+06    | 1.07E+05  | 1.32E+06  | 1.93E+06  | 1.11E+06  | 4.35E+05  | 1.39E+05  | 3.92E+04  |         |
| 2.21E-01*          | 1.08E+05*   | 3.19E+06    | 7.46E+06    | 1.19E+05* | 1.31E+06  | 1.93E+06  | 1.11E+06  | 4.37E+05  | 1.39E+05  | 3.94E+04* |         |
| 5                  | .2715       | .2886       | .3076       | .3289     | .3530     | .3805     | .4120     | .4485     | .4913     | .5421     | .6033   |
|                    | 36829.5     | 34654.6     | 32512.4     | 30402.9   | 28326.4   | 26283.2   | 24273.4   | 22297.3   | 20355.3   | 18447.7   | 16574.8 |
| 2.34E-06           | 3.94E-06    | 1.10E-02    | 2.13E-01    | 3.63E-01  | 2.07E-02  | 3.99E-02  | 1.21E-01  | 1.08E-01  | 6.50E-02  | 3.20E-02  |         |
| 1.1665             | 2.8861      | 1.3640      | 1.2496      | 1.1932    | 1.0168    | 1.0807    | 1.0394    | 1.0021    | .9724     | .9465     |         |
| 6.56E-01           | -2.23E+00   | 4.64E-01    | 5.80E-01    | 6.32E-01  | 7.77E-01  | 7.28E-01  | 7.60E-01  | 7.88E-01  | 8.09E-01  | 8.27E-01  |         |
| 1.02E+02*          | ( 1.65E+03) | 1.64E+05    | 4.07E+06    | 6.68E+06  | 4.59E+05  | 6.12E+05  | 1.57E+06  | 1.15E+06  | 5.42E+05  | 2.02E+05  |         |
| 1.10E+02*          | 3.49E+02*   | 1.72E+05    | 4.09E+06    | 6.63E+06  | 4.83E+05  | 6.07E+05  | 1.56E+06  | 1.15E+06  | 5.43E+05  | 2.03E+05  |         |
| 6                  | .2573       | .2725       | .2894       | .3082     | .3293     | .3531     | .3801     | .4109     | .4466     | .4881     | .5373   |
|                    | 38867.8     | 36692.9     | 34550.6     | 32441.2   | 30364.7   | 28321.5   | 26311.7   | 24335.6   | 22393.6   | 20486.0   | 18613.1 |
| 8.84E-08           | 1.79E-05    | 1.34E-05    | 1.43E-02    | 2.56E-01  | 3.39E-01  | 3.44E-02  | 1.32E-02  | 8.91E-02  | 1.00E-01  | 7.11E-02  |         |
| 1.5229             | 1.2327      | -.0984      | 1.3958      | 1.2617    | 1.2077    | 1.0192    | 1.0817    | 1.0467    | 1.0062    | .9774     |         |
| 2.83E-01           | 5.96E-01    | 1.03E+00    | 4.30E-01    | 5.68E-01  | 6.19E-01  | 7.76E-01  | 7.27E-01  | 7.55E-01  | 7.85E-01  | 8.06E-01  |         |
| ( 8.43E-01)        | 6.35E+02    | ( 1.18E+03) | 1.82E+05    | 4.69E+06  | 5.97E+06  | 7.64E+05  | 2.03E+05  | 1.15E+06  | 1.08E+06  | 6.03E+05  |         |
| 1.13E+00*          | 6.74E+02*   | 4.15E+03*   | 1.94E+05    | 4.72E+06  | 5.90E+06  | 8.01E+05  | 2.01E+05  | 1.15E+06  | 1.08E+06  | 6.05E+05  |         |
| 7                  | .2450       | .2588       | .2740       | .2908     | .3095     | .3304     | .3539     | .3805     | .4109     | .4458     | .4864   |
|                    | 40812.9     | 38637.9     | 36495.7     | 34386.3   | 32309.8   | 30266.5   | 28256.7   | 26280.7   | 24338.7   | 22431.1   | 20558.2 |
| 5.82E-09           | 2.53E-07    | 6.98E-05    | 2.64E-04    | 1.44E-02  | 2.90E-01  | 3.30E-01  | 3.84E-02  | 1.56E-03  | 6.09E-02  | 8.50E-02  |         |
| 1.0638             | 1.7456      | 1.2920      | .8674       | 1.4437    | 1.2751    | 1.2243    | .9936     | 1.0398    | 1.0575    | 1.0091    |         |
| 7.41E-01           | -9.81E-03   | 5.38E-01    | 8.78E-01    | 3.76E-01  | 5.55E-01  | 6.04E-01  | 7.94E-01  | 7.60E-01  | 7.46E-01  | 7.83E-01  |         |
| ( 4.41E-01)        | ( 2.84E-03) | 1.99E+03    | ( 1.68E+04) | 1.39E+05  | 5.02E+06  | 5.50E+06  | 8.90E+05  | 2.63E+04  | 7.76E+05  | 9.18E+05  |         |
| 4.98E-01*          | 3.18E-01*   | 2.11E+03*   | 2.04E+04*   | 1.54E+05  | 5.04E+06  | 5.42E+06  | 9.44E+05  | 2.64E+04* | 7.68E+05  | 9.19E+05  |         |

## TRANSITION PROBABILITIES AND RELATED DATA FOR NITROGEN AND OXYGEN BANDS 1073

Table 15. Radiative transition parameters for  $N_2^+ B^2\Sigma_u^+ - X^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . —Continued

| $v' \backslash v''$ | 11        | 12         | 13         | 14         | 15         | 16         | 17         | 18         | 19         | 20         | 21       |
|---------------------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|----------|
| 0                   | 2.8799    | 5.9878     | -103.9263  | -5.4763    | -2.8418    | -1.9327    | -1.4726    | -1.1950    | -1.0095    | -.8769     | -.7776   |
|                     | 3472.3    | 1670.1     | -96.2      | -1826.0    | -3518.8    | -5174.0    | -6790.8    | -8368.4    | -9906.2    | -11403.4   | -12859.5 |
| 2.05E-07            | 8.58E-08  | 4.12E-08   | 2.22E-08   | 1.31E-08   | 8.31E-09   | 5.55E-09   | 3.86E-09   | 2.77E-09   | 2.04E-09   | 1.54E-09   |          |
| .8633               | .8702     | .8779      | .8851      | .8909      | .8951      | .8978      | .8994      | .9001      | .9003      | .9001      |          |
| 8.80E-01            | 8.76E-01  | 8.71E-01   | 8.67E-01   | 8.63E-01   | 8.61E-01   | 8.59E-01   | 8.58E-01   | 8.58E-01   | 8.57E-01   | 8.58E-01   |          |
| 1.35E-02            | 6.21E-04  | -5.65E-08  | -2.06E-04  | -8.63E-04  | -1.73E-03  | -2.60E-03  | -3.37E-03  | -4.01E-03  | -4.51E-03  | -4.87E-03  |          |
| 1.35E-02*           | 6.21E-04* | -5.64E-08* | -2.06E-04* | -8.62E-04* | -1.73E-03* | -2.60E-03* | -3.37E-03* | -4.01E-03* | -4.51E-03* | -4.87E-03* |          |
| 1                   | 1.7112    | 2.4743     | 4.3950     | 18.3328    | -8.7159    | -3.5683    | -2.2628    | -1.6675    | -1.3272    | -1.1072    | -.9535   |
|                     | 5843.8    | 4041.6     | 2275.3     | 545.5      | -1147.3    | -2802.5    | -4419.2    | -5996.9    | -7534.7    | -9031.8    | -10488.0 |
| 5.36E-06            | 2.14E-06  | 9.74E-07   | 5.00E-07   | 2.85E-07   | 1.76E-07   | 1.15E-07   | 7.96E-08   | 5.69E-08   | 4.20E-08   | 3.17E-08   |          |
| .8643               | .8675     | .8732      | .8797      | .8859      | .8908      | .8945      | .8970      | .8985      | .8993      | .8996      |          |
| 8.80E-01            | 8.78E-01  | 8.74E-01   | 8.70E-01   | 8.67E-01   | 8.63E-01   | 8.61E-01   | 8.60E-01   | 8.59E-01   | 8.58E-01   | 8.58E-01   |          |
| 1.68E+00            | 2.20E-01  | 1.78E-02   | 1.25E-04   | -6.54E-04  | -5.84E-03  | -1.50E-02  | -2.57E-02  | -3.64E-02  | -4.61E-02  | -5.46E-02  |          |
| 1.68E+00*           | 2.21E-01* | 1.78E-02*  | 1.24E-04*  | -6.53E-04* | -5.83E-03* | -1.49E-02* | -2.57E-02* | -3.64E-02* | -4.61E-02* | -5.45E-02* |          |
| 2                   | 1.2252    | 1.5724     | 2.1770     | 3.4920     | 8.5406     | 20.6504    | 47.7596    | 2.7184     | -1.9170    | -1.4895    | -1.2240  |
|                     | 8162.0    | 6359.8     | 4593.5     | 2863.7     | 1170.9     | -484.3     | -2101.0    | -3678.7    | -5216.4    | -6713.6    | -8169.7  |
| 7.04E-05            | 2.72E-05  | 1.19E-05   | 5.84E-06   | 3.19E-06   | 1.90E-06   | 1.22E-06   | 8.30E-07   | 5.89E-07   | 4.33E-07   | 3.27E-07   |          |
| .8710               | .8694     | .8717      | .8763      | .8817      | .8868      | .8910      | .8942      | .8964      | .8978      | .8987      |          |
| 8.76E-01            | 8.77E-01  | 8.75E-01   | 8.72E-01   | 8.69E-01   | 8.66E-01   | 8.63E-01   | 8.61E-01   | 8.60E-01   | 8.59E-01   | 8.58E-01   |          |
| 5.94E+01            | 1.09E+01  | 1.79E+00   | 2.11E-01   | 7.83E-03   | -3.28E-04  | -1.71E-02  | -6.21E-02  | -1.25E-01  | -1.96E-01  | -2.66E-01  |          |
| 5.97E+01*           | 1.09E+01* | 1.79E+00*  | 2.11E-01*  | 7.82E-03*  | -3.28E-04* | -1.71E-02* | -6.21E-02* | -1.25E-01* | -1.96E-01* | -2.66E-01* |          |
| 3                   | .9595     | 1.1602     | 1.4592     | 1.9519     | 2.9150     | 5.6325     | 63.0382    | -7.0471    | -3.3820    | -2.2452    | -1.6920  |
|                     | 10421.7   | 8619.4     | 6853.2     | 5123.3     | 3450.5     | 1775.4     | 158.6      | -1419.0    | -2956.8    | -4454.0    | -5910.1  |
| 5.95E-04            | 2.30E-04  | 9.82E-05   | 4.66E-05   | 2.45E-05   | 1.41E-05   | 8.83E-06   | 5.88E-06   | 4.12E-06   | 3.00E-06   | 2.26E-06   |          |
| .8837               | .8768     | .8746      | .8760      | .8795      | .8838      | .8879      | .8914      | .8942      | .8961      | .8975      |          |
| 8.68E-01            | 8.72E-01  | 8.73E-01   | 8.73E-01   | 8.70E-01   | 8.68E-01   | 8.65E-01   | 8.63E-01   | 8.61E-01   | 8.60E-01   | 8.59E-01   |          |
| 1.03E+03            | 2.27E+02  | 4.89E+01   | 9.66E+00   | 1.52E+00   | 1.21E-01   | 5.35E-05   | -2.54E-02  | -1.60E-01  | -3.97E-01  | -6.97E-01  |          |
| 1.03E+03*           | 2.28E+02* | 4.90E+01*  | 9.68E+00*  | 1.52E+00*  | 1.21E-01*  | 5.34E-05*  | -2.53E-02* | -1.60E-01* | -3.97E-01* | -6.97E-01* |          |
| 4                   | .7926     | .9247      | 1.1053     | 1.3665     | 1.7778     | 2.5190     | 4.2499     | 12.8972    | -13.1163   | -4.4256    | -2.6913  |
|                     | 12616.1   | 10813.8    | 9047.5     | 7317.7     | 5624.9     | 3969.8     | 2353.0     | 775.4      | -762.4     | -2259.6    | -3715.7  |
| 3.49E-03            | 1.40E-03  | 6.02E-04   | 2.81E-04   | 1.44E-04   | 8.06E-05   | 4.89E-05   | 3.18E-05   | 2.19E-05   | 1.58E-05   | 1.18E-05   |          |
| .9020               | .8899     | .8827      | .8799      | .8804      | .8828      | .8861      | .8893      | .8922      | .8945      | .8961      |          |
| 8.56E-01            | 8.64E-01  | 8.68E-01   | 8.70E-01   | 8.70E-01   | 8.68E-01   | 8.65E-01   | 8.63E-01   | 8.61E-01   | 8.60E-01   | 8.60E-01   |          |
| 1.04E+04            | 2.69E+03  | 6.81E+02   | 1.69E+02   | 3.92E+01   | 7.70E+00   | 9.69E-01   | 2.25E-02   | -1.46E-02  | -2.74E-01  | -9.06E-01  |          |
| 1.05E+04*           | 2.70E+03* | 6.84E+02*  | 1.69E+02*  | 3.93E+01*  | 7.71E+00*  | 9.70E-01*  | 2.25E-02*  | -1.46E-02* | -2.74E-01* | -9.06E-01* |          |
| 5                   | .6786     | .7731      | .8954      | 1.0595     | 1.2910     | 1.6418     | 2.2351     | 3.4526     | 7.3604     | -72.1709   | -6.2709  |
|                     | 14737.1   | 12934.8    | 11168.6    | 9438.7     | 7765.9     | 6090.8     | 4474.0     | 2896.4     | 1358.6     | -138.6     | -1594.7  |
| 1.43E-02            | 6.20E-03  | 2.82E-03   | 1.33E-03   | 6.75E-04   | 3.71E-04   | 2.20E-04   | 1.40E-04   | 9.47E-05   | 6.72E-05   | 4.97E-05   |          |
| .9251               | .9082     | .8961      | .8887      | .8853      | .8849      | .8863      | .8886      | .8910      | .8932      | .8950      |          |
| 8.41E-01            | 8.52E-01  | 8.60E-01   | 8.65E-01   | 8.67E-01   | 8.67E-01   | 8.66E-01   | 8.65E-01   | 8.63E-01   | 8.62E-01   | 8.61E-01   |          |
| 6.59E+04            | 2.00E+04  | 5.88E+03   | 1.69E+03   | 4.77E+02   | 1.28E+02   | 3.00E+01   | 5.16E+00   | 3.59E-01   | -2.69E-04  | -3.03E-01  |          |
| 6.62E+04            | 2.01E+04* | 5.91E+03*  | 1.70E+03*  | 4.79E+02*  | 1.28E+02*  | 3.00E+01*  | 5.16E+00*  | 3.59E-01*  | -2.69E-04* | -3.02E-01* |          |
| 6                   | .5961     | .6679      | .7572      | .8713      | 1.0221     | 1.2301     | 1.5355     | 2.0265     | 2.9439     | 5.2639     | 22.5423  |
|                     | 16775.4   | 14973.1    | 13206.9    | 11477.0    | 9784.2     | 8129.1     | 6512.3     | 4934.7     | 3396.9     | 1899.7     | 443.6    |
| 4.01E-02            | 2.04E-02  | 9.98E-03   | 4.95E-03   | 2.56E-03   | 1.40E-03   | 8.23E-04   | 5.16E-04   | 3.43E-04   | 2.40E-04   | 1.76E-04   |          |
| .9517               | .9308     | .9143      | .9023      | .8946      | .8907      | .8894      | .8899      | .8913      | .8929      | .8945      |          |
| 8.24E-01            | 8.38E-01  | 8.49E-01   | 8.56E-01   | 8.61E-01   | 8.64E-01   | 8.64E-01   | 8.64E-01   | 8.63E-01   | 8.62E-01   | 8.61E-01   |          |
| 2.60E+05            | 9.72E+04  | 3.35E+04   | 1.11E+04   | 3.60E+03   | 1.14E+03   | 3.44E+02   | 9.38E+01   | 2.03E+01   | 2.48E+00   | 2.30E-02   |          |
| 2.61E+05            | 9.76E+04  | 3.37E+04*  | 1.12E+04*  | 3.61E+03*  | 1.14E+03*  | 3.45E+02*  | 9.39E+01*  | 2.03E+01*  | 2.48E+00*  | 2.30E-02*  |          |
| 7                   | .5342     | .5911      | .6600      | .7450      | .8526      | .9926      | 1.1824     | 1.4535     | 1.8720     | 2.6009     | 4.1864   |
|                     | 18720.4   | 16918.2    | 15151.9    | 13422.1    | 11729.3    | 10074.1    | 8457.4     | 6879.7     | 5342.0     | 3844.8     | 2388.7   |
| 7.12E-02            | 4.56E-02  | 2.61E-02   | 1.42E-02   | 7.75E-03   | 4.36E-03   | 2.57E-03   | 1.61E-03   | 1.06E-03   | 7.33E-04   | 5.31E-04   |          |
| .9822               | .9565     | .9363      | .9202      | .9083      | .9005      | .8960      | .8940      | .8936      | .8941      | .8951      |          |
| 8.02E-01            | 8.20E-01  | 8.34E-01   | 8.45E-01   | 8.52E-01   | 8.57E-01   | 8.60E-01   | 8.61E-01   | 8.62E-01   | 8.61E-01   | 8.61E-01   |          |
| 6.09E+05            | 3.01E+05  | 1.28E+05   | 4.96E+04   | 1.84E+04   | 6.64E+03   | 2.33E+03   | 7.86E+02   | 2.43E+02   | 6.26E+01   | 1.09E+01   |          |
| 6.10E+05            | 3.02E+05  | 1.28E+05   | 4.98E+04   | 1.85E+04   | 6.66E+03*  | 2.34E+03*  | 7.88E+02*  | 2.43E+02*  | 6.27E+01*  | 1.09E+01*  |          |

Table 15. Radiative transition parameters for  $N_2^+ B^2\Sigma_u^+ - X^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . —Continued

| $V' \setminus V''$ | 0           | 1           | 2           | 3           | 4           | 5           | 6         | 7           | 8           | 9         | 10          |
|--------------------|-------------|-------------|-------------|-------------|-------------|-------------|-----------|-------------|-------------|-----------|-------------|
| 8                  | .2344       | .2470       | .2609       | .2760       | .2928       | .3115       | .3323     | .3556       | .3820       | .4120     | .4465       |
|                    | 42653.3     | 40478.3     | 38336.1     | 36226.7     | 34150.2     | 32106.9     | 30097.1   | 28121.1     | 26179.1     | 24271.4   | 22398.6     |
|                    | 3.03E-10    | 9.94E-08    | 3.77E-08    | 1.77E-04    | 1.39E-03    | 1.03E-02    | 3.11E-01  | 3.43E-01    | 3.16E-02    | 7.97E-04  | 3.92E-02    |
|                    | 1.6528      | 1.1988      | 3.9364      | 1.3553      | 1.0785      | 1.5331      | 1.2900    | 1.2426      | .9262       | 1.2930    | 1.0779      |
|                    | 1.18E-01    | 6.27E-01    | -5.35E+00   | 4.73E-01    | 7.30E-01    | 2.71E-01    | 5.40E-01  | 5.86E-01    | 8.41E-01    | 5.37E-01  | 7.30E-01    |
| ( 6.61E-04)        | 5.25E+00    | ( 1.23E+02) | 3.81E+03    | 6.00E+04    | ( 5.07E+04) | 5.02E+06    | 5.31E+06  | 8.13E+05    | 6.66E+03    | 4.76E+05  |             |
|                    | 2.15E-03*   | 5.68E+00*   | 1.88E+01*   | 4.11E+03*   | 6.49E+04*   | 6.55E+04    | 5.04E+06  | 5.20E+06    | 8.96E+05    | 6.36E+03* | 4.66E+05    |
| 9                  | .2253       | .2370       | .2496       | .2635       | .2788       | .2956       | .3143     | .3351       | .3584       | .3847     | .4145       |
|                    | 44377.3     | 42202.3     | 40060.1     | 37950.6     | 35874.2     | 33830.9     | 31821.1   | 29845.0     | 27903.0     | 25995.4   | 24122.6     |
|                    | 2.83E-11    | 5.02E-10    | 6.81E-07    | 2.21E-06    | 2.93E-04    | 4.52E-03    | 3.36E-03  | 3.12E-01    | 3.77E-01    | 1.75E-02  | 8.71E-03    |
|                    | 1.2048      | 2.4759      | 1.2983      | .6988       | 1.4415      | 1.1812      | 1.8162    | 1.3067      | 1.2614      | .7461     | 1.2359      |
|                    | 6.22E-01    | -1.29E+00   | 5.32E-01    | 9.66E-01    | 3.79E-01    | 6.43E-01    | -1.12E-01 | 5.23E-01    | 5.68E-01    | 9.44E-01  | 5.93E-01    |
| ( 1.93E-03)        | ( 1.28E-01) | 2.51E+01    | ( 2.29E+02) | ( 3.93E+03) | 1.47E+05    | ( 2.77E+03) | 4.60E+06  | 5.35E+06    | ( 5.55E+05) | 8.70E+04  |             |
|                    | 2.35E-03*   | 2.74E-02*   | 2.70E+01*   | 3.24E+02*   | 4.51E+03*   | 1.53E+05*   | 1.90E+02* | 4.61E+06    | 5.23E+06    | 6.94E+05  | 8.20E+04*   |
| 10                 | .2175       | .2283       | .2401       | .2529       | .2669       | .2823       | .2992     | .3180       | .3390       | .3624     | .3888       |
|                    | 45975.1     | 43800.2     | 41657.9     | 39548.5     | 37472.0     | 35428.7     | 33418.9   | 31442.9     | 29500.9     | 27593.3   | 25720.4     |
|                    | 3.47E-12    | 8.65E-10    | 5.91E-09    | 2.36E-06    | 3.23E-05    | 2.50E-04    | 1.06E-02  | 3.01E-04    | 2.79E-01    | 4.27E-01  | 3.74E-03    |
|                    | 1.4757      | 1.3592      | .3943       | 1.4072      | 1.0955      | 1.6252      | 1.2510    | -.6894      | 1.3262      | 1.2791    | -.0365      |
|                    | 3.39E-01    | 4.69E-01    | 1.06E+00    | 4.17E-01    | 7.16E-01    | 1.54E-01    | 5.78E-01  | 6.90E-01    | 5.03E-01    | 5.51E-01  | 1.04E+00    |
|                    | 7.87E-05    | ( 3.24E-02) | ( 9.70E-01) | ( 5.15E+01) | 1.77E+03    | ( 5.36E+02) | 2.68E+05  | ( 9.03E+03) | 3.68E+06    | 5.52E+06  | ( 1.40E+05) |
|                    | 7.40E-05*   | 3.90E-02*   | 1.81E+00*   | 5.78E+01*   | 1.95E+03*   | 1.13E+03*   | 2.76E+05  | 1.17E+05*   | 3.69E+06    | 5.37E+06  | 4.23E+05*   |
| $V' \setminus V''$ | 11          | 12          | 13          | 14          | 15          | 16          | 17        | 18          | 19          | 20        | 21          |
| 8                  | .4864       | .5331       | .5885       | .6552       | .7369       | .8393       | .9711     | 1.1468      | 1.3923      | 1.7590    | 2.3646      |
|                    | 20560.8     | 18758.6     | 16992.3     | 15262.5     | 13569.7     | 11914.5     | 10297.8   | 8720.1      | 7182.4      | 5685.2    | 4229.1      |
|                    | 6.58E-02    | 6.56E-02    | 4.75E-02    | 3.03E-02    | 1.82E-02    | 1.09E-02    | 6.63E-03  | 4.20E-03    | 2.77E-03    | 1.92E-03  | 1.38E-03    |
|                    | 1.0094      | .9876       | .9609       | .9414       | .9259       | .9142       | .9060     | .9011       | .8986       | .8974     | .8971       |
|                    | 7.83E-01    | 7.99E-01    | 8.17E-01    | 8.31E-01    | 8.41E-01    | 8.49E-01    | 8.54E-01  | 8.57E-01    | 8.59E-01    | 8.59E-01  |             |
|                    | 7.10E+05    | 5.60E+05    | 3.15E+05    | 1.50E+05    | 6.53E+04    | 2.69E+04    | 1.07E+04  | 4.14E+03    | 1.53E+03    | 5.26E+02  | 1.56E+02    |
|                    | 7.11E+05    | 5.59E+05    | 3.16E+05    | 1.51E+05    | 6.56E+04    | 2.70E+04    | 1.07E+04* | 4.15E+03*   | 1.54E+03*   | 5.27E+02* | 1.56E+02*   |
| 9                  | .4487       | .4882       | .5343       | .5887       | .6539       | .7332       | .8318     | .9575       | 1.1228      | 1.3497    | 1.6798      |
|                    | 22284.8     | 20482.6     | 18716.3     | 16986.5     | 15293.7     | 13638.5     | 12021.8   | 10444.1     | 8906.3      | 7409.2    | 5953.0      |
|                    | 2.47E-02    | 4.56E-02    | 5.58E-02    | 4.51E-02    | 3.20E-02    | 2.12E-02    | 1.38E-02  | 9.03E-03    | 6.08E-03    | 4.24E-03  | 3.07E-03    |
|                    | 1.1218      | 1.0034      | .9944       | .9647       | .9463       | .9310       | .9199     | .9115       | .9059       | .9029     | .9013       |
|                    | 6.94E-01    | 7.87E-01    | 7.94E-01    | 8.15E-01    | 8.27E-01    | 8.38E-01    | 8.45E-01  | 8.50E-01    | 8.54E-01    | 8.56E-01  | 8.57E-01    |
|                    | 2.67E+05    | 4.91E+05    | 4.67E+05    | 2.97E+05    | 1.59E+05    | 7.63E+04    | 3.46E+04  | 1.51E+04    | 6.35E+03    | 2.56E+03  | 9.63E+02    |
|                    | 2.57E+05    | 4.95E+05    | 4.65E+05    | 2.98E+05    | 1.59E+05    | 7.66E+04    | 3.47E+04  | 1.51E+04*   | 6.37E+03*   | 2.57E+03* | 9.64E+02*   |
| 10                 | .4187       | .4529       | .4923       | .5381       | .5920       | .6563       | .7342     | .8304       | .9520       | 1.1102    | 1.3244      |
|                    | 23882.6     | 22080.4     | 20314.1     | 18584.3     | 16891.5     | 15236.4     | 13619.6   | 12041.9     | 10504.2     | 9007.0    | 7550.9      |
|                    | 2.61E-02    | 1.68E-02    | 2.70E-02    | 4.39E-02    | 3.90E-02    | 3.07E-02    | 2.22E-02  | 1.56E-02    | 1.10E-02    | 7.86E-03  | 5.76E-03    |
|                    | 1.2595      | 1.2100      | .9808       | 1.0048      | .9675       | .9513       | .9354     | .9251       | .9169       | .9107     | .9068       |
|                    | 5.70E-01    | 6.17E-01    | 8.03E-01    | 7.86E-01    | 8.13E-01    | 8.24E-01    | 8.35E-01  | 8.41E-01    | 8.47E-01    | 8.51E-01  | 8.53E-01    |
|                    | 2.34E+05    | 1.40E+05    | 2.96E+05    | 3.53E+05    | 2.52E+05    | 1.49E+05    | 7.90E+04  | 3.92E+04    | 1.85E+04    | 8.42E+03  | 3.66E+03    |
|                    | 2.18E+05    | 1.30E+05    | 3.03E+05    | 3.50E+05    | 2.52E+05    | 1.50E+05    | 7.93E+04  | 3.93E+04    | 1.86E+04    | 8.44E+03* | 3.66E+03*   |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 16. Radiative transition parameters for  $N_2^+ C^2\Sigma_u^+ - X^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $v' \backslash v''$ | 0           | 1           | 2           | 3           | 4           | 5           | 6         | 7           | 8           | 9           | 10      |
|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|-----------|-------------|-------------|-------------|---------|
| 0                   | .1549       | .1603       | .1660       | .1721       | .1785       | .1852       | .1924     | .2000       | .2080       | .2166       | .2258   |
|                     | 64540.1     | 62365.2     | 60223.0     | 58113.5     | 56037.1     | 53993.8     | 51984.0   | 50007.9     | 48065.9     | 46158.3     | 44285.5 |
| 1.19E-02            | 7.15E-02    | 1.87E-01    | 2.77E-01    | 2.52E-01    | 1.43E-01    | 4.86E-02    | 8.65E-03  | 5.36E-04    | 9.97E-08    | 5.24E-06    |         |
| 1.1948              | 1.2126      | 1.2318      | 1.2527      | 1.2762      | 1.3037      | 1.3384      | 1.3889    | 1.4959      | -2.6964     | 1.3347      |         |
| 1.31E-01            | 1.47E-01    | 1.66E-01    | 1.86E-01    | 2.10E-01    | 2.36E-01    | 2.66E-01    | 3.00E-01  | 3.06E-01    | 0.00E+00    | 2.63E-01    |         |
| 1.11E+05            | 7.62E+05    | 2.27E+06    | 3.82E+06    | 3.94E+06    | 2.54E+06    | 9.80E+05    | 1.97E+05  | ( 1.13E+04) | ( 0.00E+00) | ( 6.40E+01) |         |
| 1.13E+05            | 7.71E+05    | 2.28E+06    | 3.81E+06    | 3.93E+06    | 2.54E+06    | 1.00E+06    | 2.16E+05* | 1.87E+04*   | 7.43E+01*   | 1.27E+02*   |         |
| 1                   | .1502       | .1552       | .1606       | .1662       | .1722       | .1784       | .1851     | .1921       | .1995       | .2074       | .2158   |
|                     | 66591.7     | 64416.7     | 62274.5     | 60165.0     | 58088.6     | 56045.3     | 54035.5   | 52059.5     | 50117.5     | 48209.9     | 46337.0 |
| 4.50E-02            | 1.52E-01    | 1.61E-01    | 3.14E-02    | 2.92E-02    | 1.90E-01    | 2.36E-01    | 1.24E-01  | 2.86E-02    | 1.87E-03    | 8.17E-06    |         |
| 1.1780              | 1.1940      | 1.2100      | 1.2203      | 1.2692      | 1.2830      | 1.3089      | 1.3434    | 1.3954      | 1.5143      | .4444       |         |
| 1.16E-01            | 1.30E-01    | 1.45E-01    | 1.55E-01    | 2.03E-01    | 2.16E-01    | 2.41E-01    | 2.70E-01  | 3.03E-01    | 2.98E-01    | 3.71E-07    |         |
| 3.63E+05            | 1.39E+06    | 1.65E+06    | 3.31E+05    | 4.75E+05    | 3.17E+06    | 4.38E+06    | 2.60E+06  | 6.67E+05    | ( 3.77E+04) | ( 2.26E-10) |         |
| 3.71E+05            | 1.41E+06    | 1.65E+06    | 3.25E+05    | 4.74E+05    | 3.13E+06    | 4.34E+06    | 2.62E+06  | 7.26E+05    | 6.76E+04*   | 2.92E+01*   |         |
| 2                   | .1457       | .1505       | .1555       | .1608       | .1663       | .1722       | .1784     | .1849       | .1918       | .1990       | .2068   |
|                     | 68620.8     | 66445.9     | 64303.6     | 62194.2     | 60117.7     | 58074.5     | 56064.7   | 54088.6     | 52146.6     | 50239.0     | 48366.2 |
| 9.10E-02            | 1.55E-01    | 3.09E-02    | 3.44E-02    | 1.19E-01    | 1.94E-02    | 5.97E-02    | 2.35E-01  | 1.96E-01    | 5.67E-02    | 3.77E-03    |         |
| 1.1626              | 1.1772      | 1.1884      | 1.2184      | 1.2299      | 1.2281      | 1.2990      | 1.3160    | 1.3493      | 1.4026      | 1.5363      |         |
| 1.03E-01            | 1.15E-01    | 1.25E-01    | 1.53E-01    | 1.64E-01    | 1.62E-01    | 2.32E-01    | 2.47E-01  | 2.75E-01    | 3.06E-01    | 2.85E-01    |         |
| 6.36E+05            | 1.22E+06    | 2.61E+05    | 3.91E+05    | 1.40E+06    | 2.02E+05    | 1.14E+06    | 4.60E+06  | 4.25E+06    | 1.36E+06    | ( 7.01E+04) |         |
| 6.49E+05            | 1.22E+06    | 2.48E+05    | 4.07E+05    | 1.41E+06    | 2.06E+05    | 1.10E+06    | 4.48E+06  | 4.23E+06    | 1.47E+06    | 1.41E+05*   |         |
| 3                   | .1416       | .1461       | .1508       | .1558       | .1610       | .1664       | .1722     | .1783       | .1847       | .1914       | .1985   |
|                     | 70625.0     | 68450.1     | 66307.8     | 64198.4     | 62121.9     | 60078.7     | 58068.9   | 56092.8     | 54150.8     | 52243.2     | 50370.3 |
| 1.31E-01            | 8.92E-02    | 5.45E-03    | 9.61E-02    | 1.49E-02    | 5.40E-02    | 8.17E-02    | 2.72E-03  | 1.81E-01    | 2.49E-01    | 8.89E-02    |         |
| 1.1483              | 1.1613      | 1.1905      | 1.1950      | 1.1994      | 1.2373      | 1.2445      | 1.4128    | 1.3264      | 1.3561      | 1.4104      |         |
| 9.22E-02            | 1.02E-01    | 1.27E-01    | 1.31E-01    | 1.35E-01    | 1.71E-01    | 1.78E-01    | 3.09E-01  | 2.56E-01    | 2.80E-01    | 3.08E-01    |         |
| 7.92E+05            | 6.06E+05    | ( 5.18E+04) | 8.83E+05    | 1.32E+05    | 6.94E+05    | 1.03E+06    | 9.29E+04  | 3.84E+06    | 5.62E+06    | 2.19E+06    |         |
| 8.05E+05            | 5.93E+05    | 6.00E+04*   | 8.90E+05    | 1.23E+05    | 7.13E+05    | 1.05E+06    | 9.32E+04* | 3.65E+06    | 5.50E+06    | 2.34E+06    |         |
| 4                   | .1377       | .1420       | .1464       | .1511       | .1560       | .1611       | .1665     | .1722       | .1782       | .1844       | .1910   |
|                     | 72601.6     | 70426.7     | 68284.4     | 66175.0     | 64098.5     | 62055.3     | 60045.5   | 58069.4     | 56127.4     | 54219.8     | 52347.0 |
| 1.49E-01            | 2.35E-02    | 5.65E-02    | 4.60E-02    | 2.17E-02    | 7.00E-02    | 1.99E-03    | 9.04E-02  | 9.01E-03    | 1.20E-01    | 2.82E-01    |         |
| 1.1349              | 1.1452      | 1.1659      | 1.1760      | 1.2030      | 1.2100      | 1.2851      | 1.2506    | 1.1950      | 1.3422      | 1.3642      |         |
| 8.24E-02            | 8.99E-02    | 1.06E-01    | 1.14E-01    | 1.38E-01    | 1.45E-01    | 2.18E-01    | 1.84E-01  | 1.31E-01    | 2.69E-01    | 2.85E-01    |         |
| 7.86E+05            | 1.34E+05    | 4.09E+05    | 3.53E+05    | 2.21E+05    | 7.10E+05    | ( 4.15E+04) | 1.22E+06  | ( 5.53E+04) | 2.80E+06    | 6.67E+06    |         |
| 7.94E+05            | 1.23E+05    | 4.26E+05    | 3.39E+05    | 2.38E+05    | 7.06E+05    | 4.66E+04*   | 1.25E+06  | 7.87E+04*   | 2.57E+06    | 6.38E+06    |         |
| 5                   | .1341       | .1382       | .1424       | .1468       | .1514       | .1562       | .1613     | .1666       | .1722       | .1780       | .1842   |
|                     | 74548.1     | 72373.2     | 70230.9     | 68121.5     | 66045.0     | 64001.8     | 61992.0   | 60015.9     | 58073.9     | 56166.3     | 54293.4 |
| 1.45E-01            | 6.38E-06    | 8.10E-02    | 6.82E-04    | 6.79E-02    | 3.76E-03    | 6.22E-02    | 1.27E-02  | 5.76E-02    | 3.59E-02    | 6.99E-02    |         |
| 1.1224              | .8947       | 1.1503      | 1.1309      | 1.1807      | 1.1738      | 1.2151      | 1.2100    | 1.2570      | 1.2359      | 1.3676      |         |
| 7.40E-02            | 4.90E-03    | 9.37E-02    | 7.97E-02    | 1.18E-01    | 1.12E-01    | 1.50E-01    | 1.45E-01  | 1.91E-01    | 1.70E-01    | 2.87E-01    |         |
| 6.64E+05            | ( 1.18E-01) | 4.99E+05    | ( 2.77E+03) | 5.55E+05    | ( 2.53E+04) | 6.71E+05    | 1.16E+05  | 8.29E+05    | ( 3.71E+05) | ( 1.87E+06) |         |
| 6.64E+05            | 5.99E+02*   | 5.03E+05    | 9.40E+02*   | 5.63E+05    | 1.96E+04*   | 6.87E+05    | 1.10E+05  | 8.68E+05    | 4.53E+05    | 1.63E+06    |         |
| 6                   | .1308       | .1346       | .1386       | .1428       | .1471       | .1517       | .1565     | .1615       | .1667       | .1722       | .1779   |
|                     | 76461.8     | 74286.9     | 72144.6     | 70035.2     | 67958.7     | 65915.5     | 63905.7   | 61929.6     | 59987.6     | 58080.0     | 56207.2 |
| 1.24E-01            | 1.51E-02    | 5.60E-02    | 1.98E-02    | 4.14E-02    | 2.17E-02    | 3.80E-02    | 2.23E-02  | 4.23E-02    | 2.20E-02    | 5.71E-02    |         |
| 1.1105              | 1.1283      | 1.1361      | 1.1562      | 1.1632      | 1.1872      | 1.1921      | 1.2231    | 1.2230      | 1.2683      | 1.2460      |         |
| 6.65E-02            | 7.79E-02    | 8.33E-02    | 9.82E-02    | 1.04E-01    | 1.24E-01    | 1.28E-01    | 1.57E-01  | 1.57E-01    | 2.02E-01    | 1.80E-01    |         |
| 4.96E+05            | ( 7.61E+04) | 2.96E+05    | 1.33E+05    | 2.83E+05    | 1.94E+05    | 3.31E+05    | 2.65E+05  | 4.57E+05    | 3.56E+05    | ( 6.63E+05) |         |
| 4.91E+05            | 8.58E+04    | 2.86E+05    | 1.47E+05    | 2.72E+05    | 2.10E+05    | 3.20E+05    | 2.83E+05  | 4.54E+05    | 3.84E+05    | 8.02E+05    |         |
| 7                   | .1276       | .1313       | .1351       | .1391       | .1432       | .1475       | .1520     | .1567       | .1616       | .1668       | .1722   |
|                     | 78340.2     | 76165.2     | 74023.0     | 71913.5     | 69837.1     | 67793.8     | 65784.0   | 63808.0     | 61866.0     | 59958.4     | 58085.5 |
| 9.68E-02            | 4.40E-02    | 1.86E-02    | 5.25E-02    | 3.37E-03    | 5.35E-02    | 6.24E-05    | 5.35E-02  | 7.55E-04    | 5.63E-02    | 2.93E-03    |         |
| 1.0994              | 1.1145      | 1.1215      | 1.1401      | 1.1386      | 1.1676      | 1.0304      | 1.1969    | 1.2831      | 1.2284      | 1.3110      |         |
| 5.99E-02            | 6.89E-02    | 7.34E-02    | 8.61E-02    | 8.51E-02    | 1.07E-01    | 2.92E-02    | 1.33E-01  | 2.16E-01    | 1.62E-01    | 2.43E-01    |         |
| 3.39E+05            | 1.87E+05    | ( 8.23E+04) | 2.93E+05    | ( 1.68E+04) | 3.89E+05    | ( 3.08E+01) | 4.95E+05  | ( 1.69E+04) | 6.47E+05    | ( 6.86E+04) |         |
| 3.31E+05            | 1.98E+05    | 7.29E+04    | 3.04E+05    | 1.16E+04*   | 3.95E+05    | 5.77E+02*   | 5.00E+05  | 2.16E+04*   | 6.56E+05    | 8.21E+04*   |         |

Table 16. Radiative transition parameters for  $N_2^+ C^2\Sigma_u^+-X^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}, \bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . - Continued

| $v'\backslash v''$  | 11   | 12  | 13        | 14  | 15        | 16        | 17        | 18        | 19        | 20        | 21        |           |           |
|---|--|---|-----------|---|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0   | .2356  | .2460   | .2572     | .2692   | .2820     | .2958     | .3107     | .3267     | .3440     | .3627     | .3829     |           |           |
|   | 42447.7  | 40645.5   | 38879.2   | 37149.4   | 35456.6   | 33801.5   | 32184.7   | 30607.1   | 29069.3   | 27572.2   | 26116.0   |           |           |
| 8.84E-08  | 7.47E-08   | 2.11E-09  | 2.09E-09  | 6.29E-12  | 8.02E-11  | 2.92E-12  | 1.98E-12  | 9.11E-13  | 8.54E-15  | 4.93E-14  |           |           |           |
| 1.8639  | 1.2661   | 1.8420  | 1.2832    | 3.0950  | 1.3673    | .8451     | 1.5553    | 1.2447    | .1006     | 1.4748    |           |           |           |
| 3.12E-02  | 2.00E-01   | 3.96E-02  | 2.16E-01  | 4.29E-17  | 2.87E-01  | 2.25E-03  | 2.71E-01  | 1.78E-01  | 6.66E-12  | 3.12E-01  |           |           |           |
| ( 1.33E-02)( 4.05E-01)( 3.93E-04)( 1.01E-02)( 1.05E-36)( 5.18E-04)( 1.00E-09)( 8.45E-06)( 1.44E-06)( 1.61E-29)( 1.74E-07) | 9.91E+00*  | 1.02E+00*   | 2.26E-01* | 2.41E-02*   | 3.80E-03* | 1.23E-03* | 1.38E-05* | 5.81E-05* | 3.25E-06* | 7.80E-07* | 6.58E-07* |           |           |
| 1   | .2247  | .2342   | .2443     | .2551   | .2666     | .2789     | .2921     | .3062     | .3213     | .3376     | .3550     |           |           |
|   | 44499.3  | 42697.0   | 40930.7   | 39200.9   | 37508.2   | 35853.0   | 34236.3   | 32658.6   | 31120.8   | 29623.7   | 28167.6   |           |           |
| 2.89E-05  | 6.40E-08   | 5.96E-07  | 3.02E-10  | 1.84E-08  | 3.67E-10  | 5.18E-10  | 1.14E-10  | 1.91E-12  | 9.68E-12  | 1.19E-12  |           |           |           |
| 1.3717  | 2.8880   | 1.3324  | 5.1741    | 1.3707  | .6924     | 1.4987    | 1.1816    | 2.3779    | 1.3969    | 1.0780    |           |           |           |
| 2.90E-01  | 2.37E-13   | 2.61E-01  | 0.00E+00  | 2.89E-01  | 1.36E-04  | 3.05E-01  | 1.19E-01  | 2.82E-06  | 3.03E-01  | 4.86E-02  |           |           |           |
| ( 4.34E+02)( 5.66E-25)( 5.65E+00)( 0.00E+00)( 1.65E-01)( 6.34E-10)( 3.92E-03)( 1.15E-04)( 9.29E-16)( 4.69E-05)( 1.28E-07) | 8.21E+02*  | 3.07E+01*   | 1.22E+01* | 7.66E-01*   | 5.31E-03* | 1.58E-02* | 3.18E-04* | 4.00E-04* | 1.26E-04* | 8.58E-08* |           |           |           |
| 2   | .2149  | .2236   | .2328     | .2425   | .2529     | .2640     | .2757     | .2883     | .3017     | .3159     | .3312     |           |           |
|   | 46528.4  | 44726.2   | 42959.9   | 41230.1   | 39537.3   | 37882.2   | 36265.4   | 34687.8   | 33150.0   | 31652.8   | 30196.7   |           |           |
| 6.81E-05  | 8.46E-05   | 2.14E-07  | 2.22E-06  | 3.75E-08  | 6.47E-08  | 8.93E-09  | 8.00E-10  | 9.94E-10  | 3.70E-11  | 2.71E-11  |           |           |           |
| .8790   | 1.4098   | -.1624  | 1.3969    | .6878   | 1.4674    | 1.1254    | 1.7946    | 1.3270    | .7837     | 1.6247    |           |           |           |
| 3.86E-03  | 3.08E-01   | 1.80E-16  | 3.02E-01  | 1.24E-04  | 3.14E-01  | 7.60E-02  | 6.34E-02  | 2.57E-01  | 7.86E-04  | 2.09E-01  |           |           |           |
| ( 2.08E-01)( 1.46E+03)( 1.12E-30)( 2.88E+01)( 7.18E-08)( 7.01E-01)( 4.98E-03)( 2.72E-04)( 4.84E-03)( 1.47E-09)( 6.59E-05) | 1.91E+02*  | 2.79E+03*   | 2.86E+01* | 6.26E+01*   | 4.30E-01* | 2.14E+00* | 1.75E-02* | 6.63E-02* | 1.13E-02* | 3.00E-04* | 1.01E-03* |           |           |
| 3   | .2060  | .2140   | .2224     | .2313   | .2407     | .2507     | .2613     | .2725     | .2845     | .2971     | .3106     |           |           |
|   | 48532.6  | 46730.4   | 44964.1   | 43234.3   | 41541.5   | 39886.4   | 38269.6   | 36692.0   | 35154.2   | 33657.0   | 32200.9   |           |           |
| 5.68E-03  | 2.82E-04   | 1.71E-04  | 4.86E-06  | 5.00E-06  | 4.93E-07  | 1.04E-07  | 5.82E-08  | 4.20E-11  | 3.23E-09  | 7.93E-10  |           |           |           |
| 1.5633  | 1.0571   | 1.4522  | .8914     | 1.4663  | 1.0903    | 1.6273    | 1.2714    | -2.9573   | 1.4612    | 1.1886    |           |           |           |
| 2.65E-01  | 3.92E-02   | 3.15E-01  | 4.66E-03  | 3.14E-01  | 5.49E-02  | 2.06E-01  | 2.05E-01  | 0.00E+00  | 3.14E-01  | 1.25E-01  |           |           |           |
| ( 9.23E+04)( 8.97E+01)( 3.13E+03)( 1.73E-02)( 7.15E+01)( 1.91E-01)( 5.00E-01)( 2.44E-01)( 0.00E+00)( 2.46E-02)( 8.42E-04) | 2.20E+05*  | 2.83E+03*   | 6.57E+03* | 2.90E-02*   | 1.92E+02* | 1.12E+00* | 6.26E+00* | 6.03E-01* | 9.40E-02* | 8.08E-02* | 2.25E-03* |           |           |
| 4   | .1980  | .2053   | .2130     | .2212   | .2298     | .2389     | .2485     | .2586     | .2693     | .2806     | .2926     |           |           |
|   | 50509.2  | 48707.0   | 46940.7   | 45210.9   | 43518.1   | 41863.0   | 40246.2   | 38668.6   | 37130.8   | 35633.7   | 34177.5   |           |           |
| 1.22E-01  | 7.06E-03   | 8.04E-04  | 2.61E-04  | 2.67E-05  | 7.12E-06  | 2.40E-06  | 4.20E-08  | 1.87E-07  | 1.42E-08  | 3.52E-09  |           |           |           |
| 1.4191  | 1.5975   | 1.1574  | 1.5040    | 1.1152  | 1.5688    | 1.2318    | 2.2272    | 1.3751    | .9937     | 1.7252    |           |           |           |
| 3.11E-01  | 2.35E-01   | 9.92E-02  | 3.03E-01  | 6.94E-02  | 2.60E-01  | 1.66E-01  | 9.05E-05  | 2.92E-01  | 1.89E-02  | 1.13E-01  |           |           |           |
| 3.07E+06  | ( 9.11E+04)( 1.66E+03)( 4.48E+03)( 2.14E+01)( 7.17E+01)( 8.69E+00)( 4.03E-08)( 1.66E+00)( 4.67E-04)( 3.66E-03) | 3.23E+06  | 2.82E+05* | 1.30E+04*   | 1.18E+04* | 1.79E+02* | 3.94E+02* | 2.58E+01* | 9.64E+00* | 3.88E+00* | 9.54E-04* | 2.37E-01* |           |
| 5   | .1906  | .1974   | .2046     | .2121   | .2200     | .2283     | .2370     | .2462     | .2559     | .2661     | .2768     |           |           |
|   | 52455.7  | 50653.5   | 48887.2   | 47157.4   | 45464.6   | 43809.5   | 42192.7   | 40615.1   | 39077.3   | 37580.1   | 36124.0   |           |           |
| 3.01E-01  | 1.53E-01   | 7.51E-03  | 1.79E-03  | 3.05E-04  | 8.57E-05  | 5.54E-06  | 6.92E-06  | 5.92E-08  | 3.28E-07  | 1.04E-07  |           |           |           |
| 1.3735  | 1.4285   | 1.6426  | 1.2243    | 1.5754  | 1.2231    | 1.7815    | 1.3212    | .2081     | 1.4935    | 1.2249    |           |           |           |
| 2.91E-01  | 3.13E-01   | 1.91E-01  | 1.58E-01  | 2.55E-01  | 1.57E-01  | 7.15E-02  | 2.52E-01  | 2.85E-10  | 3.07E-01  | 1.59E-01  |           |           |           |
| 7.47E+06  | 3.94E+06   | ( 6.48E+04)( 9.54E+03)( 3.77E+03)( 3.61E+02)( 4.30E+00)( 5.96E+01)( 5.82E-19)( 3.32E+00)( 2.51E-01) | 6.96E+06  | 4.09E+06  | 3.09E+05* | 3.79E+04* | 1.67E+04* | 1.25E+03* | 5.44E+02* | 5.19E+00* | 1.21E+01* | 6.96E-01* |           |
| 6   | .1839  | .1902   | .1968     | .2038   | .2111     | .2187     | .2267     | .2351     | .2440     | .2532     | .2629     |           |           |
|   | 54369.4  | 52567.2   | 50800.9   | 49071.1   | 47378.3   | 45723.2   | 44106.4   | 42528.8   | 40991.0   | 39493.8   | 38037.7   |           |           |
| 3.05E-02  | 3.12E-01   | 1.81E-01  | 6.92E-03  | 3.34E-03  | 2.61E-04  | 1.98E-04  | 7.76E-07  | 1.35E-05  | 1.22E-06  | 2.54E-07  |           |           |           |
| 1.4108  | 1.3842   | 1.4388  | 1.7055    | 1.2742  | 1.6929    | 1.2945    | 3.0289    | 1.3998    | 1.0457    | 1.7345    |           |           |           |
| 3.09E-01  | 2.97E-01   | 3.14E-01  | 1.30E-01  | 2.08E-01  | 1.42E-01  | 2.27E-01  | 7.63E-16  | 3.04E-01  | 3.47E-02  | 1.06E-01  |           |           |           |
| ( 1.13E+06)( 8.10E+06)  | 4.76E+06   | ( 2.82E+04)( 3.10E+04)( 1.02E+03)( 1.78E+03)( 7.04E-29)( 1.74E+02)( 1.83E-01)( 3.16E-01)            | 9.59E+05  | 7.32E+06  | 4.86E+06  | 2.93E+05* | 8.45E+04* | 1.86E+04* | 4.28E+03* | 4.51E+02* | 3.96E+02* | 1.04E+00* | 2.12E+01* |
| 7   | .1778  | .1837   | .1898     | .1963   | .2030     | .2101     | .2175     | .2252     | .2333     | .2417     | .2505     |           |           |
|   | 56247.8  | 54445.5   | 52679.3   | 50949.5   | 49256.7   | 47601.5   | 45984.8   | 44407.1   | 42869.4   | 41372.2   | 39916.1   |           |           |
| 6.51E-02  | 1.69E-02   | 3.18E-01  | 2.06E-01  | 5.46E-03  | 5.42E-03  | 1.36E-04  | 3.56E-04  | 3.98E-06  | 1.79E-05  | 5.34E-06  |           |           |           |
| 1.2502  | 1.4893   | 1.3962  | 1.4499    | 1.8004  | 1.3148    | 1.9604    | 1.3521    | .4211     | 1.4921    | 1.2238    |           |           |           |
| 1.84E-01  | 3.09E-01   | 3.03E-01  | 3.15E-01  | 6.00E-02  | 2.46E-01  | 9.35E-03  | 2.77E-01  | 1.96E-07  | 3.08E-01  | 1.58E-01  |           |           |           |
| ( 7.92E+05)   | 5.25E+05   | ( 8.65E+06)   | 5.48E+06  | ( 4.76E+03)( 7.17E+04)( 2.34E+00)( 4.83E+03)( 2.44E-11)( 2.43E+02)( 1.72E+01) | 9.83E+05  | 5.20E+05  | 7.55E+06  | 5.50E+06  | 2.35E+05* | 1.56E+05* | 1.00E+04* | 1.13E+02* | 5.39E+01* |

Table 16. Radiative transition parameters for  $N_2^+ C ^2\Sigma_u^+ - X ^2\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . – Continued

| $v' \backslash v''$ | 0           | 1           | 2           | 3           | 4           | 5           | 6           | 7           | 8           | 9           | 10      |
|---------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------|
| 8                   | .1247       | .1282       | .1318       | .1356       | .1395       | .1436       | .1479       | .1523       | .1570       | .1618       | .1669   |
|                     | 80180.5     | 78005.6     | 75863.4     | 73753.9     | 71677.4     | 69634.2     | 67624.4     | 65648.3     | 63706.3     | 61798.7     | 59925.9 |
| 7.04E-02            | 6.65E-02    | 5.37E-04    | 5.49E-02    | 7.68E-03    | 3.43E-02    | 2.33E-02    | 1.72E-02    | 3.75E-02    | 6.14E-03    | 4.96E-02    |         |
| 1.0888              | 1.1028      | 1.0869      | 1.1267      | 1.1486      | 1.1514      | 1.1729      | 1.1752      | 1.2017      | 1.1905      | 1.2350      |         |
| 5.41E-02            | 6.19E-02    | 5.31E-02    | 7.68E-02    | 9.24E-02    | 9.45E-02    | 1.12E-01    | 1.14E-01    | 1.37E-01    | 1.27E-01    | 1.67E-01    |         |
| 2.15E+05            | 2.45E+05    | ( 1.34E+03) | 2.63E+05    | ( 4.89E+04) | 2.10E+05    | 1.82E+05    | 1.27E+05    | 3.68E+05    | ( 4.73E+04) | 6.02E+05    |         |
| 2.09E+05            | 2.52E+05    | 2.58E+02*   | 2.61E+05    | 5.89E+04*   | 1.99E+05    | 1.99E+05    | 1.16E+05    | 3.85E+05    | 4.04E+04*   | 6.20E+05    |         |
| 9                   | .1220       | .1253       | .1288       | .1324       | .1361       | .1400       | .1440       | .1483       | .1527       | .1572       | .1620   |
|                     | 81980.3     | 79805.4     | 77663.1     | 75553.7     | 73477.2     | 71434.0     | 69424.2     | 67448.1     | 65506.1     | 63598.5     | 61725.6 |
| 4.85E-02            | 7.51E-02    | 5.90E-03    | 3.25E-02    | 3.31E-02    | 4.66E-03    | 4.40E-02    | 1.08E-03    | 3.75E-02    | 1.33E-02    | 2.29E-02    |         |
| 1.0789              | 1.0921      | 1.1116      | 1.1138      | 1.1312      | 1.1306      | 1.1557      | 1.2010      | 1.1813      | 1.2099      | 1.2051      |         |
| 4.91E-02            | 5.59E-02    | 6.71E-02    | 6.85E-02    | 7.99E-02    | 7.95E-02    | 9.78E-02    | 1.36E-01    | 1.19E-01    | 1.45E-01    | 1.40E-01    |         |
| 1.30E+05            | 2.41E+05    | ( 2.52E+04) | 1.33E+05    | 1.70E+05    | ( 2.17E+04) | 2.86E+05    | ( 1.25E+04) | 3.01E+05    | 1.45E+05    | 2.15E+05    |         |
| 1.25E+05            | 2.44E+05    | 3.12E+04*   | 1.24E+05    | 1.81E+05    | 1.57E+04*   | 2.90E+05    | 1.80E+04*   | 2.96E+05    | 1.60E+05    | 2.06E+05    |         |
| 10                  | .1194       | .1226       | .1259       | .1293       | .1329       | .1366       | .1405       | .1445       | .1487       | .1530       | .1575   |
|                     | 83737.1     | 81562.2     | 79420.0     | 77310.5     | 75234.1     | 73190.8     | 71181.0     | 69204.9     | 67262.9     | 65355.3     | 63482.5 |
| 3.21E-02            | 7.17E-02    | 2.29E-02    | 9.49E-03    | 4.50E-02    | 3.05E-03    | 2.83E-02    | 2.39E-02    | 6.04E-03    | 3.87E-02    | 6.54E-04    |         |
| 1.0696              | 1.0822      | 1.0971      | 1.0997      | 1.1183      | 1.1441      | 1.1407      | 1.1607      | 1.1578      | 1.1856      | 1.2602      |         |
| 4.47E-02            | 5.07E-02    | 5.86E-02    | 6.01E-02    | 7.13E-02    | 8.91E-02    | 8.66E-02    | 1.02E-01    | 9.95E-02    | 1.23E-01    | 1.96E-01    |         |
| 7.62E+04            | 2.03E+05    | 7.99E+04    | ( 3.21E+04) | 1.98E+05    | ( 1.92E+04) | 1.55E+05    | 1.66E+05    | ( 3.69E+04) | 3.29E+05    | ( 1.27E+04) |         |
| 7.21E+04            | 2.01E+05    | 8.81E+04    | 2.59E+04*   | 2.00E+05    | 2.58E+04*   | 1.46E+05    | 1.80E+05    | 2.92E+04*   | 3.37E+05    | 1.75E+04*   |         |
| $v' \backslash v''$ | 11          | 12          | 13          | 14          | 15          | 16          | 17          | 18          | 19          | 20          | 21      |
| 8                   | .1722       | .1777       | .1834       | .1894       | .1957       | .2023       | .2091       | .2162       | .2237       | .2314       | .2395   |
|                     | 58088.1     | 56285.9     | 54519.6     | 52789.8     | 51097.0     | 49441.9     | 47825.1     | 46247.5     | 44709.7     | 43212.6     | 41756.4 |
| 8.08E-04            | 6.18E-02    | 6.59E-03    | 3.24E-01    | 2.27E-01    | 3.51E-03    | 7.81E-03    | 1.40E-05    | 5.14E-04    | 3.89E-05    | 1.47E-05    |         |
| 1.1275              | 1.2519      | 1.6474      | 1.4095      | 1.4619      | 1.9625      | 1.3500      | 3.6013      | 1.4065      | 1.0314      | 1.6456      |         |
| 7.74E-02            | 1.85E-01    | 1.86E-01    | 3.08E-01    | 3.14E-01    | 9.09E-03    | 2.75E-01    | 2.31E-28    | 3.07E-01    | 2.96E-02    | 1.88E-01    |         |
| ( 1.92E+03)         | ( 7.68E+05) | ( 7.50E+04) | ( 9.15E+06) | 6.08E+06    | ( 7.10E+01) | ( 1.31E+05) | ( 0.00E+00) | ( 8.78E+03) | ( 5.56E+00) | ( 7.67E+01) |         |
| 1.67E+02*           | 1.00E+06    | 2.55E+05    | 7.69E+06    | 5.99E+06    | 1.53E+05*   | 2.50E+05*   | 8.14E+03    | 1.81E+04    | 1.01E+02*   | 1.04E+03*   |         |
| 9                   | .1670       | .1722       | .1776       | .1832       | .1890       | .1952       | .2015       | .2081       | .2150       | .2222       | .2296   |
|                     | 59887.9     | 58085.7     | 56319.4     | 54589.6     | 52896.8     | 51241.7     | 49624.9     | 48047.3     | 46509.5     | 45012.3     | 43556.2 |
| 3.23E-02            | 8.72E-03    | 5.19E-02    | 1.92E-03    | 3.29E-01    | 2.45E-01    | 1.61E-03    | 1.02E-02    | 5.25E-05    | 5.99E-04    | 1.30E-04    |         |
| 1.2384              | 1.2140      | 1.2521      | 2.0316      | 1.4238      | 1.4747      | 2.3096      | 1.3826      | .0716       | 1.4660      | 1.1973      |         |
| 1.72E-01            | 1.49E-01    | 1.86E-01    | 3.27E-03    | 3.12E-01    | 3.12E-01    | 1.47E-05    | 2.96E-01    | 2.28E-12    | 3.14E-01    | 1.35E-01    |         |
| 4.16E+05            | ( 7.64E+04) | ( 6.48E+05) | ( 6.79E+00) | ( 9.61E+06) | 6.52E+06    | ( 8.58E-05) | ( 2.01E+05) | ( 5.58E-20) | ( 1.09E+04) | ( 3.86E+02) |         |
| 4.37E+05            | 6.49E+04*   | 9.12E+05    | 1.06E+05*   | 7.75E+06    | 6.31E+06    | 6.87E+04*   | 3.54E+05    | 1.05E+03*   | 2.59E+04*   | 1.62E+03*   |         |
| 10                  | .1622       | .1671       | .1722       | .1775       | .1830       | .1887       | .1946       | .2008       | .2072       | .2138       | .2207   |
|                     | 61644.7     | 59842.5     | 58076.2     | 56346.4     | 54653.6     | 52998.5     | 51381.7     | 49804.1     | 48266.3     | 46769.2     | 45313.1 |
| 3.57E-02            | 1.50E-02    | 1.95E-02    | 3.98E-02    | 2.63E-04    | 3.35E-01    | 2.59E-01    | 2.99E-04    | 1.22E-02    | 4.19E-04    | 5.48E-04    |         |
| 1.2109              | 1.2469      | 1.2281      | 1.2511      | 3.5337      | 1.4392      | 1.4883      | 3.6530      | 1.4147      | .8852       | 1.5437      |         |
| 1.46E-01            | 1.80E-01    | 1.62E-01    | 1.85E-01    | 1.10E-26    | 3.15E-01    | 3.09E-01    | 1.11E-29    | 3.10E-01    | 4.25E-03    | 2.80E-01    |         |
| 3.59E+05            | 2.12E+05    | 2.03E+05    | ( 4.91E+05) | ( 0.00E+00) | 1.00E+07    | 6.78E+06    | ( 0.00E+00) | ( 2.67E+05) | ( 1.56E+00) | ( 8.09E+03) |         |
| 3.56E+05            | 2.30E+05    | 1.87E+05    | 7.74E+05    | 3.04E+04*   | 7.75E+06    | 6.44E+06    | 1.07E+04*   | 4.53E+05    | 2.15E+03*   | 3.01E+04*   |         |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 17. Radiative transition parameters for  $O_2^+ A^2\Pi_u - X^2\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ .

| $V' \backslash V''$ | 0         | 1         | 2         | 3         | 4         | 5         | 6         | 7         | 8        | 9           | 10    |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-------------|-------|
| 0                   | .2496     | .2618     | .2751     | .2895     | .3051     | .3223     | .3411     | .3617     | .3846    | .4100       | .4384 |
| 40068.1             | 38195.0   | 36354.7   | 34547.2   | 32772.4   | 31030.3   | 29320.7   | 27643.7   | 25999.3   | 24387.4  | 22808.2     |       |
| 1.60E-06            | 3.00E-05  | 2.66E-04  | 1.50E-03  | 5.96E-03  | 1.79E-02  | 4.22E-02  | 7.98E-02  | 1.23E-01  | 1.58E-01 | 1.69E-01    |       |
| 1.2432              | 1.2583    | 1.2738    | 1.2897    | 1.3061    | 1.3230    | 1.3405    | 1.3585    | 1.3772    | 1.3967   | 1.4169      |       |
| 1.92E-01            | 1.97E-01  | 2.01E-01  | 2.07E-01  | 2.12E-01  | 2.18E-01  | 2.25E-01  | 2.32E-01  | 2.40E-01  | 2.49E-01 | 2.59E-01    |       |
| 7.69E+00            | 1.31E+02  | 1.05E+03  | 5.33E+03  | 1.91E+04  | 5.17E+04  | 1.09E+05  | 1.84E+05  | 2.54E+05  | 2.89E+05 | 2.72E+05    |       |
| 7.76E+00*           | 1.32E+02* | 1.06E+03* | 5.37E+03* | 1.93E+04* | 5.19E+04  | 1.10E+05  | 1.85E+05  | 2.55E+05  | 2.89E+05 | 2.72E+05    |       |
| 1                   | .2443     | .2560     | .2686     | .2823     | .2972     | .3135     | .3312     | .3507     | .3721    | .3959       | .4223 |
| 40939.7             | 39066.6   | 37226.3   | 35418.9   | 33644.1   | 31901.9   | 30192.3   | 28515.3   | 26870.9   | 25259.1  | 23679.8     |       |
| 1.31E-05            | 2.13E-04  | 1.60E-03  | 7.44E-03  | 2.36E-02  | 5.37E-02  | 8.90E-02  | 1.06E-01  | 8.43E-02  | 3.51E-02 | 1.18E-03    |       |
| 1.2362              | 1.2510    | 1.2661    | 1.2816    | 1.2975    | 1.3139    | 1.3307    | 1.3480    | 1.3656    | 1.3829   | 1.3855      |       |
| 1.90E-01            | 1.94E-01  | 1.99E-01  | 2.04E-01  | 2.09E-01  | 2.15E-01  | 2.21E-01  | 2.28E-01  | 2.35E-01  | 2.43E-01 | 2.44E-01    |       |
| 6.57E+01            | 9.70E+02  | 6.64E+03  | 2.78E+04  | 7.97E+04  | 1.63E+05  | 2.43E+05  | 2.59E+05  | 1.84E+05  | 6.77E+04 | 1.88E+03    |       |
| 6.62E+01*           | 9.76E+02* | 6.68E+03* | 2.80E+04* | 8.01E+04  | 1.64E+05  | 2.44E+05  | 2.59E+05  | 1.83E+05  | 6.70E+04 | 1.75E+03*   |       |
| 2                   | .2393     | .2506     | .2627     | .2758     | .2900     | .3054     | .3222     | .3406     | .3608    | .3831       | .4078 |
| 41784.0             | 39910.9   | 38070.6   | 36263.1   | 34488.3   | 32746.2   | 31036.6   | 29359.6   | 27715.2   | 26103.3  | 24524.1     |       |
| 5.67E-05            | 7.99E-04  | 5.11E-03  | 1.94E-02  | 4.80E-02  | 7.91E-02  | 8.32E-02  | 4.64E-02  | 4.84E-03  | 1.09E-02 | 5.75E-02    |       |
| 1.2296              | 1.2440    | 1.2588    | 1.2739    | 1.2894    | 1.3052    | 1.3213    | 1.3373    | 1.3486    | 1.3812   | 1.3962      |       |
| 1.88E-01            | 1.92E-01  | 1.97E-01  | 2.01E-01  | 2.06E-01  | 2.12E-01  | 2.18E-01  | 2.24E-01  | 2.28E-01  | 2.42E-01 | 2.49E-01    |       |
| 2.97E+02            | 3.80E+03  | 2.21E+04  | 7.60E+04  | 1.70E+05  | 2.53E+05  | 2.39E+05  | 1.19E+05  | 1.09E+04  | 2.30E+04 | 1.06E+05    |       |
| 2.99E+02*           | 3.83E+03* | 2.22E+04* | 7.63E+04  | 1.71E+05  | 2.53E+05  | 2.39E+05  | 1.19E+05  | 1.06E+04* | 2.35E+04 | 1.07E+05    |       |
| 3                   | .2347     | .2455     | .2572     | .2697     | .2832     | .2979     | .3139     | .3314     | .3505    | .3715       | .3946 |
| 42600.9             | 40727.8   | 38887.6   | 37080.1   | 35305.3   | 33563.1   | 31853.5   | 30176.5   | 28532.1   | 26920.3  | 25341.0     |       |
| 1.73E-04            | 2.12E-03  | 1.14E-02  | 3.52E-02  | 6.60E-02  | 7.30E-02  | 3.80E-02  | 1.64E-03  | 1.76E-02  | 5.71E-02 | 4.69E-02    |       |
| 1.2232              | 1.2374    | 1.2518    | 1.2665    | 1.2816    | 1.2968    | 1.3118    | 1.3172    | 1.3516    | 1.3666   | 1.3829      |       |
| 1.86E-01            | 1.90E-01  | 1.95E-01  | 1.99E-01  | 2.04E-01  | 2.09E-01  | 2.14E-01  | 2.16E-01  | 2.30E-01  | 2.36E-01 | 2.43E-01    |       |
| 9.44E+02            | 1.05E+04  | 5.15E+04  | 1.44E+05  | 2.45E+05  | 2.44E+05  | 1.14E+05  | 4.26E+03  | 4.37E+04  | 1.25E+05 | 9.13E+04    |       |
| 9.50E+02*           | 1.06E+04* | 5.18E+04  | 1.44E+05  | 2.45E+05  | 2.44E+05  | 1.14E+05  | 4.05E+03* | 4.43E+04  | 1.26E+05 | 9.08E+04    |       |
| 4                   | .2305     | .2409     | .2520     | .2641     | .2770     | .2911     | .3063     | .3229     | .3410    | .3609       | .3827 |
| 43390.6             | 41517.5   | 39677.3   | 37869.8   | 36095.0   | 34352.8   | 32643.3   | 30966.3   | 29321.8   | 27710.0  | 26130.7     |       |
| 4.20E-04            | 4.45E-03  | 2.02E-02  | 4.96E-02  | 6.77E-02  | 4.34E-02  | 4.08E-03  | 1.26E-02  | 4.86E-02  | 3.53E-02 | 8.16E-04    |       |
| 1.2172              | 1.2311    | 1.2452    | 1.2596    | 1.2741    | 1.2886    | 1.2985    | 1.3265    | 1.3400    | 1.3550   | 1.3502      |       |
| 1.85E-01            | 1.89E-01  | 1.93E-01  | 1.97E-01  | 2.01E-01  | 2.06E-01  | 2.10E-01  | 2.20E-01  | 2.25E-01  | 2.31E-01 | 2.29E-01    |       |
| 2.37E+03            | 2.30E+04  | 9.47E+04  | 2.11E+05  | 2.62E+05  | 1.52E+05  | 1.26E+04  | 3.66E+04  | 1.26E+05  | 8.11E+04 | ( 1.55E+03) |       |
| 2.39E+03*           | 2.31E+04* | 9.51E+04  | 2.12E+05  | 2.62E+05  | 1.51E+05  | 1.23E+04* | 3.72E+04  | 1.26E+05  | 8.05E+04 | 1.40E+03*   |       |
| 5                   | .2265     | .2365     | .2473     | .2589     | .2713     | .2848     | .2993     | .3152     | .3324    | .3512       | .3718 |
| 44153.1             | 42280.0   | 40439.8   | 38632.3   | 36857.5   | 35115.3   | 33405.8   | 31728.8   | 30084.3   | 28472.5  | 26893.2     |       |
| 8.59E-04            | 7.89E-03  | 2.99E-02  | 5.75E-02  | 5.34E-02  | 1.37E-02  | 3.55E-03  | 3.76E-02  | 3.58E-02  | 1.72E-03 | 1.98E-02    |       |
| 1.2115              | 1.2252    | 1.2390    | 1.2530    | 1.2669    | 1.2796    | 1.3062    | 1.3158    | 1.3299    | 1.3332   | 1.3699      |       |
| 1.83E-01            | 1.87E-01  | 1.91E-01  | 1.95E-01  | 1.99E-01  | 2.03E-01  | 2.12E-01  | 2.16E-01  | 2.21E-01  | 2.22E-01 | 2.37E-01    |       |
| 5.04E+03            | 4.23E+04  | 1.46E+05  | 2.55E+05  | 2.15E+05  | 4.97E+04  | 1.21E+04  | 1.13E+05  | 9.65E+04  | 3.97E+03 | 4.39E+04    |       |
| 5.06E+03*           | 4.24E+04* | 1.46E+05  | 2.56E+05  | 2.15E+05  | 4.92E+04  | 1.24E+05  | 9.60E+04  | 3.75E+03* | 4.45E+04 |             |       |
| 6                   | .2228     | .2325     | .2429     | .2540     | .2660     | .2789     | .2929     | .3080     | .3245    | .3424       | .3619 |
| 44888.5             | 43015.4   | 41175.2   | 39367.7   | 37592.9   | 35850.7   | 34141.1   | 32464.1   | 30819.7   | 29207.9  | 27628.6     |       |
| 1.54E-03            | 1.23E-02  | 3.87E-02  | 5.68E-02  | 3.18E-02  | 4.03E-04  | 2.13E-02  | 3.91E-02  | 7.63E-03  | 9.66E-03 | 3.91E-02    |       |
| 1.2060              | 1.2195    | 1.2331    | 1.2466    | 1.2598    | 1.2550    | 1.2939    | 1.3071    | 1.3179    | 1.3461   | 1.3580      |       |
| 1.82E-01            | 1.85E-01  | 1.89E-01  | 1.93E-01  | 1.97E-01  | 1.96E-01  | 2.08E-01  | 2.13E-01  | 2.16E-01  | 2.27E-01 | 2.32E-01    |       |
| 9.37E+03            | 6.82E+04  | 1.96E+05  | 2.62E+05  | 1.33E+05  | 1.44E+03  | 7.44E+04  | 1.22E+05  | 2.12E+04  | 2.52E+04 | 9.01E+04    |       |
| 9.42E+03*           | 6.85E+04  | 1.96E+05  | 2.62E+05  | 1.32E+05  | 1.33E+03* | 7.50E+04  | 1.22E+05  | 2.07E+04* | 2.57E+04 | 9.02E+04    |       |
| 7                   | .2193     | .2287     | .2388     | .2495     | .2611     | .2735     | .2869     | .3015     | .3172    | .3343       | .3529 |
| 45596.8             | 43723.7   | 41883.5   | 40076.0   | 38301.2   | 36559.0   | 34849.4   | 33172.4   | 31528.0   | 29916.2  | 28336.9     |       |
| 2.51E-03            | 1.73E-02  | 4.48E-02  | 4.85E-02  | 1.27E-02  | 4.16E-03  | 3.41E-02  | 2.06E-02  | 7.94E-02  | 2.98E-02 | 2.16E-02    |       |
| 1.2009              | 1.2142    | 1.2274    | 1.2406    | 1.2523    | 1.2762    | 1.2859    | 1.2984    | 1.3363    | 1.3344   | 1.3472      |       |
| 1.81E-01            | 1.84E-01  | 1.88E-01  | 1.91E-01  | 1.95E-01  | 2.02E-01  | 2.05E-01  | 2.10E-01  | 2.23E-01  | 2.23E-01 | 2.28E-01    |       |
| 1.57E+04            | 9.91E+04  | 2.35E+05  | 2.31E+05  | 5.49E+04  | 1.68E+04  | 1.23E+05  | 6.70E+04  | 2.52E+03  | 8.02E+04 | 5.17E+04    |       |
| 1.58E+04*           | 9.95E+04  | 2.35E+05  | 2.31E+05  | 5.44E+04  | 1.72E+04* | 1.23E+05  | 6.64E+04  | 2.69E+03* | 8.06E+04 | 5.12E+04    |       |

Table 17. Radiative transition parameters for  $O_2^+ A^2\Pi_u - X^2\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . — Continued

| $V'\backslash V''$ | 11        | 12        | 13        | 14        | 15        | 16        | 17          | 18        | 19        | 20        | 21      |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|---------|
| 0                  | .4703     | .5064     | .5474     | .5946     | .6492     | .7132     | .7891       | .8805     | .9925     | 1.1328    | 1.3134  |
|                    | 21261.6   | 19747.7   | 18266.6   | 16818.4   | 15403.2   | 14021.2   | 12672.5     | 11357.2   | 10075.5   | 8827.7    | 7614.0  |
| 1.51E-01           | 1.14E-01  | 7.22E-02  | 3.84E-02  | 1.72E-02  | 6.39E-03  | 1.97E-03  | 4.96E-04    | 1.01E-04  | 1.64E-05  | 2.05E-06  |         |
| 1.4379             | 1.4600    | 1.4831    | 1.5075    | 1.5333    | 1.5608    | 1.5903    | 1.6220      | 1.6567    | 1.6949    | 1.7379    |         |
| 2.70E-01           | 2.82E-01  | 2.95E-01  | 3.10E-01  | 3.27E-01  | 3.46E-01  | 3.68E-01  | 3.94E-01    | 4.24E-01  | 4.59E-01  | 5.03E-01  |         |
| 2.14E+05           | 1.41E+05  | 7.75E+04  | 3.56E+04  | 1.36E+04  | 4.27E+03  | 1.10E+03  | 2.28E+02    | 3.76E+01  | 4.81E+00  | 4.64E-01  |         |
| 2.14E+05           | 1.41E+05  | 7.72E+04  | 3.54E+04  | 1.35E+04  | 4.23E+03* | 1.08E+03* | 2.25E+02*   | 3.69E+01* | 4.70E+00* | 4.51E-01* |         |
| 1                  | .4518     | .4850     | .5225     | .5653     | .6144     | .6715     | .7383       | .8177     | .9135     | 1.0310    | 1.1785  |
|                    | 22133.2   | 20619.3   | 19138.2   | 17690.0   | 16274.9   | 14892.8   | 13544.1     | 12228.8   | 10947.1   | 9699.3    | 8485.6  |
| 1.77E-02           | 7.51E-02  | 1.28E-01  | 1.41E-01  | 1.13E-01  | 7.01E-02  | 3.41E-02  | 1.32E-02    | 4.04E-03  | 9.76E-04  | 1.83E-04  |         |
| 1.4314             | 1.4498    | 1.4712    | 1.4941    | 1.5185    | 1.5444    | 1.5721    | 1.6017      | 1.6338    | 1.6689    | 1.7076    |         |
| 2.66E-01           | 2.76E-01  | 2.88E-01  | 3.02E-01  | 3.17E-01  | 3.34E-01  | 3.54E-01  | 3.77E-01    | 4.03E-01  | 4.35E-01  | 4.72E-01  |         |
| 2.76E+04           | 1.02E+05  | 1.51E+05  | 1.44E+05  | 9.94E+04  | 5.24E+04  | 2.15E+04  | 6.94E+03    | 1.75E+03  | 3.41E+02  | 5.05E+01  |         |
| 2.81E+04           | 1.02E+05  | 1.51E+05  | 1.44E+05  | 9.91E+04  | 5.22E+04  | 2.14E+04  | 6.87E+03    | 1.72E+03* | 3.35E+02* | 4.94E+01* |         |
| 2                  | .4352     | .4659     | .5004     | .5395     | .5841     | .6354     | .6950       | .7649     | .8481     | .9484     | 1.0718  |
|                    | 22977.5   | 21463.6   | 19982.5   | 18534.3   | 17119.1   | 15737.1   | 14388.3     | 13073.0   | 11791.4   | 10543.6   | 9329.8  |
| 7.77E-02           | 4.11E-02  | 1.64E-03  | 2.15E-02  | 8.72E-02  | 1.35E-01  | 1.29E-01  | 8.66E-02    | 4.33E-02  | 1.65E-02  | 4.77E-03  |         |
| 1.4143             | 1.4326    | 1.4345    | 1.4866    | 1.5065    | 1.5302    | 1.5560    | 1.5837      | 1.6136    | 1.6460    | 1.6814    |         |
| 2.58E-01           | 2.67E-01  | 2.68E-01  | 2.97E-01  | 3.09E-01  | 3.25E-01  | 3.43E-01  | 3.63E-01    | 3.87E-01  | 4.14E-01  | 4.46E-01  |         |
| 1.27E+05           | 5.86E+04  | 1.90E+03  | 2.45E+04  | 8.48E+04  | 1.12E+05  | 9.10E+04  | 5.16E+04    | 2.15E+04  | 6.70E+03  | 1.56E+03  |         |
| 1.27E+05           | 5.81E+04  | 1.74E+03* | 2.50E+04  | 8.54E+04  | 1.12E+05  | 9.09E+04  | 5.14E+04    | 2.13E+04  | 6.63E+03  | 1.54E+03* |         |
| 3                  | .4203     | .4488     | .4808     | .5168     | .5575     | .6041     | .6577       | .7199     | .7931     | .8802     | .9855   |
|                    | 23794.4   | 22280.5   | 20799.5   | 19351.3   | 17936.1   | 16554.0   | 15205.3     | 13890.0   | 12608.3   | 11360.5   | 10146.8 |
| 5.23E-03           | 1.39E-02  | 6.27E-02  | 6.38E-02  | 1.52E-02  | 5.65E-03  | 6.59E-02  | 1.29E-01    | 1.34E-01  | 9.13E-02  | 4.42E-02  |         |
| 1.3935             | 1.4307    | 1.4465    | 1.4656    | 1.4821    | 1.5308    | 1.5439    | 1.5685      | 1.5960    | 1.6260    | 1.6586    |         |
| 2.48E-01           | 2.66E-01  | 2.74E-01  | 2.85E-01  | 2.94E-01  | 3.25E-01  | 3.34E-01  | 3.52E-01    | 3.72E-01  | 3.97E-01  | 4.25E-01  |         |
| 8.76E+03           | 2.21E+04  | 8.59E+04  | 7.60E+04  | 1.54E+04  | 5.49E+03  | 5.24E+04  | 8.64E+04    | 7.53E+04  | 4.27E+04  | 1.69E+04  |         |
| 8.43E+03*          | 2.26E+04  | 8.63E+04  | 7.57E+04  | 1.50E+04  | 5.77E+03* | 5.31E+04  | 8.68E+04    | 7.52E+04  | 4.25E+04  | 1.68E+04  |         |
| 4                  | .4068     | .4335     | .4632     | .4965     | .5340     | .5766     | .6252       | .6812     | .7464     | .8230     | .9144   |
|                    | 24584.1   | 23070.2   | 21589.2   | 20141.0   | 18725.8   | 17343.7   | 15995.0     | 14679.7   | 13398.0   | 12150.2   | 10936.5 |
| 2.37E-02           | 5.50E-02  | 2.37E-02  | 1.38E-03  | 4.56E-02  | 6.87E-02  | 2.34E-02  | 2.74E-03    | 6.28E-02  | 1.31E-01  | 1.35E-01  |         |
| 1.3977             | 1.4134    | 1.4291    | 1.4824    | 1.4802    | 1.4995    | 1.5177    | 1.5792      | 1.5833    | 1.6093    | 1.6390    |         |
| 2.50E-01           | 2.57E-01  | 2.65E-01  | 2.94E-01  | 2.93E-01  | 3.05E-01  | 3.16E-01  | 3.60E-01    | 3.63E-01  | 3.83E-01  | 4.08E-01  |         |
| 4.45E-04           | 9.05E-04  | 3.39E+04  | 1.98E+03  | 5.21E+04  | 6.75E+04  | 1.94E+04  | 2.27E+03    | 4.03E+04  | 7.01E+04  | 5.94E+04  |         |
| 4.52E+04           | 9.05E+04  | 3.34E+04  | 2.16E+03* | 5.27E+04  | 6.74E+04  | 1.90E+04  | 2.46E+03*   | 4.09E+04  | 7.04E+04  | 5.93E+04  |         |
| 5                  | .3945     | .4196     | .4474     | .4784     | .5131     | .5523     | .5967       | .6476     | .7062     | .7744     | .8548   |
|                    | 25346.6   | 23832.8   | 22351.7   | 20903.5   | 19488.3   | 18106.3   | 16757.5     | 15442.2   | 14160.6   | 12912.8   | 11699.0 |
| 4.52E-02           | 1.25E-02  | 7.19E-03  | 4.84E-02  | 3.34E-02  | 5.45E-06  | 3.91E-02  | 6.87E-02    | 2.26E-02  | 4.66E-03  | 7.45E-02  |         |
| 1.3842             | 1.3971    | 1.4332    | 1.4448    | 1.4613    | 2.0027    | 1.5152    | 1.5348      | 1.5530    | 1.6157    | 1.6245    |         |
| 2.44E-01           | 2.49E-01  | 2.67E-01  | 2.73E-01  | 2.82E-01  | 8.46E-01  | 3.15E-01  | 3.28E-01    | 3.40E-01  | 3.88E-01  | 3.96E-01  |         |
| 8.85E+04           | 2.14E+04  | 1.16E+04  | 6.69E+04  | 3.99E+04  | 4.70E+01  | 3.70E+04  | 5.51E+04    | 1.50E+04  | 3.06E+03  | 3.78E+04  |         |
| 8.84E+04           | 2.09E+04  | 1.20E+04* | 6.72E+04  | 3.94E+04  | 4.89E+01* | 3.75E+04  | 5.50E+04    | 1.46E+04  | 3.28E+03* | 3.84E+04  |         |
| 6                  | .3834     | .4070     | .4331     | .4621     | .4945     | .5307     | .5717       | .6181     | .6713     | .7327     | .8042   |
|                    | 26082.0   | 24568.1   | 23087.1   | 21638.9   | 20223.7   | 18841.6   | 17492.9     | 16177.6   | 14895.9   | 13648.1   | 12434.4 |
| 1.38E-02           | 5.49E-03  | 4.09E-02  | 2.09E-02  | 2.64E-03  | 4.40E-02  | 3.48E-02  | 1.36E-05    | 4.23E-02  | 6.67E-02  | 1.45E-02  |         |
| 1.3705             | 1.4043    | 1.4141    | 1.4282    | 1.4739    | 1.4772    | 1.4939    | 1.9035      | 1.5511    | 1.5714    | 1.5870    |         |
| 2.37E-01           | 2.53E-01  | 2.58E-01  | 2.65E-01  | 2.90E-01  | 2.91E-01  | 3.01E-01  | 7.03E-01    | 3.39E-01  | 3.54E-01  | 3.66E-01  |         |
| 2.81E+04           | 1.05E+04  | 6.76E+04  | 3.00E+04  | 3.71E+03  | 5.07E+04  | 3.43E+04  | ( 5.76E+01) | 3.25E+04  | 4.30E+04  | 7.53E+03  |         |
| 2.75E+04           | 1.09E+04* | 6.78E+04  | 2.95E+04  | 3.95E+03* | 5.10E+04  | 3.39E+04  | 6.83E+01*   | 3.30E+04  | 4.28E+04  | 7.22E+03  |         |
| 7                  | .3733     | .3956     | .4203     | .4475     | .4777     | .5115     | .5494       | .5922     | .6409     | .6966     | .7609   |
|                    | 26790.3   | 25276.4   | 23795.4   | 22347.2   | 20932.0   | 19549.9   | 18201.2     | 16885.9   | 15604.2   | 14356.4   | 13142.7 |
| 8.04E-04           | 3.18E-02  | 2.13E-02  | 1.65E-03  | 3.70E-02  | 2.25E-02  | 2.48E-03  | 4.47E-02    | 3.02E-02  | 1.21E-03  | 5.28E-02  |         |
| 1.3927             | 1.3869    | 1.4001    | 1.4458    | 1.4448    | 1.4589    | 1.5097    | 1.5105      | 1.5269    | 1.6050    | 1.5882    |         |
| 2.47E-01           | 2.45E-01  | 2.51E-01  | 2.74E-01  | 2.73E-01  | 2.81E-01  | 3.11E-01  | 3.12E-01    | 3.22E-01  | 3.80E-01  | 3.66E-01  |         |
| 1.92E+03           | 6.22E+04  | 3.66E+04  | 2.80E+03  | 5.13E+04  | 2.69E+04  | 2.94E+03  | 4.24E+04    | 2.42E+04  | 1.04E+03  | 3.26E+04  |         |
| 2.08E+03*          | 6.26E+04  | 3.61E+04  | 3.01E+03* | 5.16E+04  | 2.65E+04  | 3.16E+03* | 4.27E+04    | 2.37E+04  | 1.17E+03* | 3.30E+04  |         |

Table 17. Radiative transition parameters for  $O_2^+ A^2\Pi_u - X^2\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . - Continued

| $v' \backslash v''$ | 0         | 1        | 2        | 3         | 4         | 5         | 6         | 7         | 8           | 9         | 10        |
|---------------------|-----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-------------|-----------|-----------|
| 8                   | .2161     | .2252    | .2349    | .2454     | .2565     | .2685     | .2814     | .2954     | .3105       | .3268     | .3446     |
|                     | 46278.1   | 44405.0  | 42564.7  | 40757.2   | 38982.4   | 37240.3   | 35530.7   | 33853.7   | 32209.3     | 30597.4   | 29018.2   |
|                     | 3.75E-03  | 2.23E-02 | 4.72E-02 | 3.57E-02  | 2.00E-03  | 1.58E-02  | 3.21E-02  | 3.79E-03  | 1.35E-02    | 2.95E-02  | 1.74E-03  |
|                     | 1.1959    | 1.2091   | 1.2221   | 1.2347    | 1.2412    | 1.2666    | 1.2786    | 1.2868    | 1.3135      | 1.3253    | 1.3275    |
|                     | 1.79E-01  | 1.83E-01 | 1.86E-01 | 1.90E-01  | 1.91E-01  | 1.99E-01  | 2.03E-01  | 2.06E-01  | 2.15E-01    | 2.19E-01  | 2.20E-01  |
|                     | 2.43E+04  | 1.32E+05 | 2.56E+05 | 1.76E+05  | 8.78E+03  | 6.54E+04  | 1.20E+05  | 1.26E+04  | 4.23E+04    | 8.22E+04  | 4.17E+03  |
|                     | 2.44E+04* | 1.33E+05 | 2.56E+05 | 1.76E+05  | 8.53E+03* | 6.60E+04  | 1.20E+05  | 1.22E+04* | 4.29E+04    | 8.20E+04  | 3.93E+03* |
| 9                   | .2131     | .2219    | .2314    | .2415     | .2523     | .2639     | .2764     | .2898     | .3043       | .3200     | .3370     |
|                     | 46932.4   | 45059.3  | 43219.0  | 41411.5   | 39636.7   | 37894.5   | 36185.0   | 34508.0   | 32863.6     | 31251.7   | 29672.5   |
|                     | 5.24E-03  | 2.69E-02 | 4.60E-02 | 2.23E-02  | 3.19E-04  | 2.55E-02  | 2.02E-02  | 4.76E-04  | 2.54E-02    | 1.35E-02  | 3.90E-03  |
|                     | 1.1913    | 1.2043   | 1.2170   | 1.2290    | 1.2660    | 1.2598    | 1.2714    | 1.3101    | 1.3047      | 1.3159    | 1.3450    |
|                     | 1.78E-01  | 1.82E-01 | 1.85E-01 | 1.88E-01  | 1.99E-01  | 1.97E-01  | 2.01E-01  | 2.14E-01  | 2.12E-01    | 2.16E-01  | 2.27E-01  |
|                     | 3.49E+04  | 1.65E+05 | 2.57E+05 | 1.13E+05  | 1.59E+03  | 1.09E+05  | 7.80E+04  | 1.81E+03  | 8.20E+04    | 3.88E+04  | 1.06E+04  |
|                     | 3.51E+04* | 1.65E+05 | 2.57E+05 | 1.13E+05  | 1.70E+03* | 1.09E+05  | 7.75E+04  | 1.95E+03* | 8.23E+04    | 3.83E+04  | 1.10E+04* |
| 10                  | .2103     | .2189    | .2281    | .2379     | .2484     | .2596     | .2716     | .2846     | .2986       | .3137     | .3300     |
|                     | 47559.7   | 45686.6  | 43846.3  | 42038.8   | 40264.0   | 38521.9   | 36812.3   | 35135.3   | 33490.9     | 31879.0   | 30299.8   |
|                     | 6.93E-03  | 3.07E-02 | 4.16E-02 | 1.12E-02  | 4.84E-03  | 2.83E-02  | 7.66E-03  | 7.83E-03  | 2.51E-02    | 1.35E-03  | 1.70E-02  |
|                     | 1.1868    | 1.1998   | 1.2123   | 1.2231    | 1.2445    | 1.2536    | 1.2635    | 1.2870    | 1.2972      | 1.2987    | 1.3318    |
|                     | 1.77E-01  | 1.80E-01 | 1.84E-01 | 1.86E-01  | 1.92E-01  | 1.95E-01  | 1.98E-01  | 2.06E-01  | 2.09E-01    | 2.10E-01  | 2.22E-01  |
|                     | 4.75E+04  | 1.93E+05 | 2.40E+05 | 5.84E+04  | 2.37E+04  | 1.25E+05  | 3.04E+04  | 2.91E+04  | 8.35E+04    | 3.88E+03  | 4.72E+04  |
|                     | 4.77E+04* | 1.94E+05 | 2.39E+05 | 5.79E+04  | 2.41E+04* | 1.25E+05  | 2.99E+04* | 2.95E+04* | 8.33E+04    | 3.67E+03* | 4.77E+04  |
| 11                  | .2076     | .2160    | .2250    | .2345     | .2447     | .2556     | .2673     | .2798     | .2933       | .3079     | .3236     |
|                     | 48160.2   | 46287.0  | 44446.8  | 42639.3   | 40864.5   | 39122.3   | 37412.8   | 35735.8   | 34091.3     | 32479.5   | 30900.2   |
|                     | 8.75E-03  | 3.34E-02 | 3.52E-02 | 3.83E-03  | 1.16E-02  | 2.45E-02  | 8.00E-04  | 1.69E-02  | 1.55E-02    | 1.59E-03  | 2.31E-02  |
|                     | 1.1826    | 1.1955   | 1.2077   | 1.2162    | 1.2375    | 1.2479    | 1.2474    | 1.2791    | 1.2898      | 1.3200    | 1.3233    |
|                     | 1.76E-01  | 1.79E-01 | 1.82E-01 | 1.85E-01  | 1.90E-01  | 1.93E-01  | 1.93E-01  | 2.03E-01  | 2.07E-01    | 2.17E-01  | 2.18E-01  |
|                     | 6.15E+04  | 2.16E+05 | 2.09E+05 | 2.05E+04  | 5.83E+04  | 1.11E+05  | 3.17E+03  | 6.44E+04  | 5.32E+04    | 5.22E+03  | 6.58E+04  |
|                     | 6.17E+04* | 2.16E+05 | 2.08E+05 | 2.02E+04* | 5.87E+04  | 1.11E+05  | 3.00E+03* | 6.49E+04  | 5.28E+04    | 5.46E+03* | 6.59E+04  |
| 12                  | .2052     | .2134    | .2221    | .2314     | .2413     | .2519     | .2635     | .2754     | .2885       | .3025     | .3177     |
|                     | 48733.8   | 46860.7  | 45020.4  | 43212.9   | 41438.1   | 39696.0   | 37986.4   | 36309.4   | 34665.0     | 33053.1   | 31473.9   |
|                     | 1.06E-02  | 3.47E-02 | 2.79E-02 | 4.28E-04  | 1.75E-02  | 1.71E-02  | 6.79E-04  | 2.12E-02  | 5.35E-03    | 9.40E-03  | 1.77E-02  |
|                     | 1.1786    | 1.1914   | 1.2034   | 1.2014    | 1.2320    | 1.2422    | 1.2742    | 1.2726    | 1.2812      | 1.3057    | 1.3156    |
|                     | 1.75E-01  | 1.78E-01 | 1.81E-01 | 1.81E-01  | 1.89E-01  | 1.92E-01  | 2.01E-01  | 2.01E-01  | 2.04E-01    | 2.12E-01  | 2.16E-01  |
|                     | 7.65E+04  | 2.31E+05 | 1.70E+05 | 2.29E+03  | 8.99E+04  | 7.95E+04  | 3.06E+03  | 8.32E+04  | 1.87E+04    | 3.09E+04  | 5.20E+04  |
|                     | 7.68E+04  | 2.31E+05 | 1.69E+05 | 2.17E+03* | 9.03E+04  | 7.91E+04  | 3.22E+03* | 8.33E+04  | 1.83E+04*   | 3.14E+04* | 5.17E+04  |
| 13                  | .2029     | .2109    | .2195    | .2285     | .2382     | .2485     | .2595     | .2713     | .2840       | .2976     | .3123     |
|                     | 49280.6   | 47407.5  | 45567.3  | 43759.8   | 41985.0   | 40242.8   | 38533.2   | 36856.2   | 35211.8     | 33600.0   | 32020.7   |
|                     | 1.24E-02  | 3.49E-02 | 2.07E-02 | 2.52E-04  | 2.07E-02  | 9.31E-03  | 4.88E-03  | 1.95E-02  | 3.01E-04    | 1.63E-02  | 7.87E-03  |
|                     | 1.1747    | 1.1876   | 1.1993   | 1.2329    | 1.2271    | 1.2364    | 1.2587    | 1.2667    | 1.2555      | 1.2981    | 1.3073    |
|                     | 1.74E-01  | 1.77E-01 | 1.80E-01 | 1.89E-01  | 1.88E-01  | 1.90E-01  | 1.97E-01  | 1.99E-01  | 1.96E-01    | 2.09E-01  | 2.13E-01  |
|                     | 9.18E+04  | 2.38E+05 | 1.29E+05 | 1.53E+03  | 1.09E+05  | 4.44E+04  | 2.19E+04  | 7.83E+04  | ( 1.02E+03) | 5.51E+04  | 2.37E+04  |
|                     | 9.21E+04  | 2.38E+05 | 1.28E+05 | 1.62E+03* | 1.10E+05  | 4.40E+04* | 2.22E+04* | 7.82E+04  | 9.16E+02*   | 5.54E+04  | 2.33E+04* |
| 14                  | .2008     | .2086    | .2170    | .2258     | .2353     | .2453     | .2561     | .2675     | .2799       | .2931     | .3073     |
|                     | 49800.8   | 47927.7  | 46087.4  | 44279.9   | 42505.1   | 40763.0   | 39053.4   | 37376.4   | 35732.0     | 34120.1   | 32540.9   |
|                     | 1.42E-02  | 3.40E-02 | 1.42E-02 | 2.18E-03  | 2.10E-02  | 3.52E-03  | 1.01E-02  | 1.39E-02  | 1.09E-03    | 1.79E-02  | 1.18E-03  |
|                     | 1.1711    | 1.1840   | 1.1955   | 1.2156    | 1.2227    | 1.2295    | 1.2520    | 1.2610    | 1.2903      | 1.2918    | 1.2928    |
|                     | 1.74E-01  | 1.77E-01 | 1.79E-01 | 1.84E-01  | 1.86E-01  | 1.88E-01  | 1.95E-01  | 1.97E-01  | 2.07E-01    | 2.07E-01  | 2.08E-01  |
|                     | 1.07E+05  | 2.37E+05 | 9.07E+04 | 1.31E+04  | 1.14E+05  | 1.71E+04  | 4.62E+04  | 5.71E+04  | 4.30E+03    | 6.18E+04  | 3.54E+03  |
|                     | 1.07E+05  | 2.37E+05 | 9.02E+04 | 1.33E+04* | 1.14E+05  | 1.68E+04* | 4.66E+04  | 5.68E+04  | 4.49E+03*   | 6.18E+04  | 3.34E+03* |
| 15                  | .1988     | .2065    | .2147    | .2233     | .2326     | .2424     | .2529     | .2641     | .2760       | .2889     | .3027     |
|                     | 50294.3   | 48421.2  | 46581.0  | 44773.5   | 42998.7   | 41256.5   | 39547.0   | 37870.0   | 36225.5     | 34613.7   | 33034.4   |
|                     | 1.57E-02  | 3.23E-02 | 8.93E-03 | 5.10E-03  | 1.89E-02  | 5.35E-04  | 1.40E-02  | 7.52E-03  | 5.20E-03    | 1.44E-02  | 3.20E-04  |
|                     | 1.1677    | 1.1806   | 1.1918   | 1.2094    | 1.2185    | 1.2151    | 1.2467    | 1.2550    | 1.2778      | 1.2858    | 1.3283    |
|                     | 1.73E-01  | 1.76E-01 | 1.78E-01 | 1.83E-01  | 1.85E-01  | 1.84E-01  | 1.93E-01  | 1.96E-01  | 2.03E-01    | 2.05E-01  | 2.20E-01  |
|                     | 1.21E+05  | 2.30E+05 | 5.82E+04 | 3.10E+04  | 1.05E+05  | 2.59E+03  | 6.52E+04  | 3.16E+04  | 2.06E+04    | 5.09E+04  | 1.13E+03  |
|                     | 1.22E+05  | 2.30E+05 | 5.78E+04 | 3.13E+04* | 1.05E+05  | 2.46E+03  | 6.55E+04  | 3.13E+04* | 2.09E+04    | 5.06E+04  | 1.24E+03* |

Table 17. Radiative transition parameters for  $O_2^+ A^2\Pi_u - X^2\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \backslash V''$ | 11        | 12          | 13        | 14          | 15        | 16          | 17          | 18          | 19          | 20          | 21      |
|---------------------|-----------|-------------|-----------|-------------|-----------|-------------|-------------|-------------|-------------|-------------|---------|
| 8                   | .3640     | .3852       | .4086     | .4342       | .4627     | .4943       | .5296       | .5692       | .6140       | .6650       | .7234   |
|                     | 27471.6   | 25957.7     | 24476.6   | 23028.4     | 21613.2   | 20231.2     | 18882.4     | 17567.1     | 16285.5     | 15037.7     | 13824.0 |
| 1.85E-02            | 2.69E-02  | 3.21E-05    | 2.69E-02  | 2.28E-02    | 1.33E-03  | 3.67E-02    | 1.89E-02    | 5.51E-03    | 4.82E-02    | 1.99E-02    |         |
| 1.3629              | 1.3752    | 1.2496      | 1.4165    | 1.4296      | 1.4825    | 1.4763      | 1.4896      | 1.5374      | 1.5447      | 1.5594      |         |
| 2.34E-01            | 2.40E-01  | 1.94E-01    | 2.59E-01  | 2.65E-01    | 2.95E-01  | 2.91E-01    | 2.99E-01    | 3.30E-01    | 3.35E-01    | 3.45E-01    |         |
| 4.27E+04            | 5.46E+04  | ( 3.58E+01) | 4.46E+04  | 3.29E+04    | 1.94E+03  | 4.24E+04    | 1.86E+04    | 5.23E+03    | 3.72E+04    | 1.27E+04    |         |
| 4.32E+04            | 5.43E+04  | 1.28E+01*   | 4.50E+04  | 3.24E+04    | 2.12E+03* | 4.26E+04    | 1.82E+04    | 5.53E+03*   | 3.74E+04    | 1.23E+04    |         |
| 9                   | .3555     | .3758       | .3979     | .4222       | .4491     | .4788       | .5119       | .5488       | .5903       | .6373       | .6907   |
|                     | 28125.9   | 26612.0     | 25130.9   | 23682.7     | 22267.5   | 20885.5     | 19536.7     | 18221.4     | 16939.8     | 15692.0     | 14478.2 |
| 2.84E-02            | 5.22E-03  | 1.32E-02    | 2.72E-02  | 1.32E-04    | 2.64E-02  | 2.01E-02    | 3.16E-03    | 3.86E-02    | 1.13E-02    | 1.40E-02    |         |
| 1.3524              | 1.3602    | 1.3923      | 1.4037    | 1.3431      | 1.4467    | 1.4591      | 1.5063      | 1.5084      | 1.5188      | 1.5668      |         |
| 2.30E-01            | 2.33E-01  | 2.47E-01    | 2.53E-01  | 2.26E-01    | 2.74E-01  | 2.81E-01    | 3.09E-01    | 3.10E-01    | 3.17E-01    | 3.50E-01    |         |
| 6.76E+04            | 1.08E+04  | 2.59E+04    | 4.67E+04  | ( 1.51E+02) | 3.67E+04  | 2.40E+04    | 3.70E+03    | 3.66E+04    | 8.87E+03    | 1.06E+04    |         |
| 6.77E+04            | 1.05E+04* | 2.64E+04    | 4.65E+04  | 1.00E+02*   | 3.70E+04  | 2.36E+04    | 3.94E+03*   | 3.67E+04    | 8.53E+03    | 1.10E+04    |         |
| 10                  | .3478     | .3671       | .3882     | .4114       | .4368     | .4648       | .4959       | .5305       | .5692       | .6128       | .6620   |
|                     | 28753.2   | 27239.3     | 25758.2   | 24310.0     | 22894.8   | 21512.8     | 20164.0     | 18848.8     | 17567.1     | 16319.3     | 15105.6 |
| 1.79E-02            | 1.26E-03  | 2.62E-02    | 6.06E-03  | 1.26E-02    | 2.54E-02  | 2.14E-05    | 2.90E-02    | 1.38E-02    | 8.88E-03    | 3.85E-02    |         |
| 1.3428              | 1.3818    | 1.3801      | 1.3880    | 1.4217      | 1.4326    | 1.6854      | 1.4774      | 1.4881      | 1.5318      | 1.5412      |         |
| 2.26E-01            | 2.42E-01  | 2.42E-01    | 2.45E-01  | 2.61E-01    | 2.67E-01  | 4.50E-01    | 2.92E-01    | 2.98E-01    | 3.26E-01    | 3.32E-01    |         |
| 4.40E+04            | 3.02E+03  | 5.29E+04    | 1.06E+04  | 2.09E+04    | 3.64E+04  | ( 7.20E+01) | 3.34E+04    | 1.35E+04    | 8.29E+03    | 2.97E+04    |         |
| 4.35E+04            | 3.22E+03* | 5.30E+04    | 1.02E+04* | 2.13E+04    | 3.62E+04  | 9.46E+01*   | 3.37E+04    | 1.31E+04    | 8.64E+03*   | 2.96E+04    |         |
| 11                  | .3407     | .3592       | .3794     | .4014       | .4256     | .4522       | .4816       | .5142       | .5504       | .5910       | .6367   |
|                     | 29353.6   | 27839.8     | 26358.7   | 24910.5     | 23495.3   | 22113.3     | 20764.5     | 19449.2     | 18167.6     | 16919.8     | 15706.0 |
| 3.77E-03            | 1.29E-02  | 1.83E-02    | 9.84E-04  | 2.51E-02    | 4.32E-03  | 1.54E-02    | 2.12E-02    | 1.53E-03    | 3.18E-02    | 5.41E-03    |         |
| 1.3297              | 1.3596    | 1.3697      | 1.4146    | 1.4084      | 1.4135    | 1.4511      | 1.4617      | 1.5166      | 1.5086      | 1.5123      |         |
| 2.21E-01            | 2.33E-01  | 2.37E-01    | 2.58E-01  | 2.55E-01    | 2.57E-01  | 2.77E-01    | 2.83E-01    | 3.16E-01    | 3.11E-01    | 3.13E-01    |         |
| 9.41E+03            | 3.07E+04  | 3.81E+04    | 2.05E+03  | 4.29E+04    | 6.26E+03  | 2.14E+04    | 2.52E+04    | 1.85E+03    | 3.01E+04    | 4.16E+03    |         |
| 9.09E+03*           | 3.11E+04  | 3.78E+04    | 2.22E+03* | 4.30E+04    | 5.97E+03* | 2.18E+04    | 2.49E+04    | 2.02E+03*   | 3.02E+04    | 3.91E+03*   |         |
| 12                  | .3341     | .3519       | .3713     | .3924       | .4155     | .4408       | .4686       | .4994       | .5336       | .5716       | .6143   |
|                     | 29927.3   | 28413.4     | 26932.3   | 25484.1     | 24068.9   | 22686.9     | 21338.1     | 20022.8     | 18741.2     | 17493.4     | 16279.6 |
| 2.99E-04            | 2.09E-02  | 4.21E-03    | 1.24E-02  | 1.63E-02    | 2.05E-03  | 2.46E-02    | 1.41E-03    | 2.06E-02    | 1.38E-02    | 7.60E-03    |         |
| 1.3675              | 1.3500    | 1.3559      | 1.3874    | 1.3969      | 1.4372    | 1.4372      | 1.4295      | 1.4808      | 1.4901      | 1.5333      |         |
| 2.36E-01            | 2.29E-01  | 2.31E-01    | 2.45E-01  | 2.49E-01    | 2.69E-01  | 2.69E-01    | 2.65E-01    | 2.94E-01    | 2.99E-01    | 3.27E-01    |         |
| ( 9.07E+02)         | 5.09E+04  | 8.91E+03    | 2.50E+04  | 2.87E+04    | 3.51E+03  | 3.51E+04    | ( 1.61E+03) | 2.37E+04    | 1.34E+04    | 7.09E+03    |         |
| 1.01E+03*           | 5.10E+04  | 8.59E+03*   | 2.54E+04  | 2.84E+04    | 3.74E+03* | 3.51E+04    | 1.45E+03*   | 2.40E+04    | 1.31E+04    | 7.39E+03*   |         |
| 13                  | .3281     | .3453       | .3639     | .3842       | .4062     | .4304       | .4569       | .4862       | .5185       | .5543       | .5943   |
|                     | 30474.1   | 28960.2     | 27479.2   | 26031.0     | 24615.8   | 23233.7     | 21885.0     | 20569.7     | 19288.0     | 18040.2     | 16826.5 |
| 6.44E-03            | 1.72E-02  | 2.18E-04    | 1.99E-02  | 2.83E-03    | 1.44E-02  | 1.24E-02    | 5.26E-03    | 2.24E-02    | 4.32E-05    | 2.58E-02    |         |
| 1.3332              | 1.3416    | 1.4057      | 1.3770    | 1.3796      | 1.4153    | 1.4241      | 1.4606      | 1.4662      | 1.6704      | 1.5111      |         |
| 2.22E-01            | 2.26E-01  | 2.53E-01    | 2.40E-01  | 2.41E-01    | 2.58E-01  | 2.63E-01    | 2.82E-01    | 2.85E-01    | 4.36E-01    | 3.12E-01    |         |
| 1.82E+04            | 4.31E+04  | ( 5.90E+02) | 4.11E+04  | 4.99E+03    | 2.43E+04  | 1.81E+04    | 7.37E+03    | 2.64E+04    | ( 9.76E+01) | 2.42E+04    |         |
| 1.86E+04*           | 4.29E+04  | 6.75E+02*   | 4.12E+04  | 4.74E+03*   | 2.47E+04  | 1.78E+04    | 7.67E+03*   | 2.63E+04    | 1.27E+02*   | 2.44E+04    |         |
| 14                  | .3226     | .3392       | .3572     | .3766       | .3978     | .4210       | .4463       | .4742       | .5048       | .5388       | .5765   |
|                     | 30994.3   | 29480.4     | 27999.3   | 26551.1     | 25135.9   | 23753.9     | 22405.1     | 21089.8     | 19808.2     | 18560.4     | 17346.7 |
| 1.37E-02            | 7.90E-03  | 6.19E-03    | 1.56E-02  | 7.59E-04    | 1.95E-02  | 7.92E-04    | 1.77E-02    | 6.67E-03    | 1.14E-02    | 1.62E-02    |         |
| 1.3243              | 1.3328    | 1.3605      | 1.3679    | 1.4141      | 1.4044    | 1.3921      | 1.4437      | 1.4496      | 1.4873      | 1.4949      |         |
| 2.19E-01            | 2.22E-01  | 2.33E-01    | 2.36E-01  | 2.58E-01    | 2.55E-01  | 2.47E-01    | 2.73E-01    | 2.76E-01    | 2.97E-01    | 3.02E-01    |         |
| 3.97E+04            | 2.02E+04  | 1.50E+04    | 3.30E+04  | 1.62E+03    | 3.38E+04  | ( 1.10E+03) | 2.50E+04    | 8.00E+03    | 1.31E+04    | 1.56E+04    |         |
| 4.00E+04            | 1.99E+04* | 1.53E+04*   | 3.27E+04  | 1.76E+03*   | 3.38E+04  | 9.74E+02*   | 2.52E+04    | 7.70E+03*   | 1.34E+04    | 1.53E+04    |         |
| 15                  | .3176     | .3336       | .3510     | .3698       | .3902     | .4124       | .4367       | .4633       | .4926       | .5248       | .5605   |
|                     | 31487.8   | 29974.0     | 28492.9   | 27044.7     | 25629.5   | 24247.4     | 22898.7     | 21583.4     | 20301.8     | 19053.9     | 17840.2 |
| 1.62E-02            | 1.18E-03  | 1.32E-02    | 6.21E-03  | 7.80E-03    | 1.26E-02  | 2.69E-03    | 1.78E-02    | 9.03E-05    | 2.01E-02    | 1.27E-03    |         |
| 1.3174              | 1.3169    | 1.3508      | 1.3577    | 1.3872      | 1.3943    | 1.4304      | 1.4323      | 1.5544      | 1.4726      | 1.4600      |         |
| 2.16E-01            | 2.16E-01  | 2.29E-01    | 2.32E-01  | 2.45E-01    | 2.48E-01  | 2.66E-01    | 2.67E-01    | 3.41E-01    | 2.89E-01    | 2.82E-01    |         |
| 4.80E+04            | 3.01E+03  | 3.26E+04    | 1.34E+04  | 1.59E+04    | 2.24E+04  | 4.62E+03    | 2.58E+04    | ( 1.78E+02) | 2.35E+04    | ( 1.16E+03) |         |
| 4.80E+04            | 2.83E+03* | 3.28E+04    | 1.31E+04* | 1.63E+04*   | 2.21E+04  | 4.86E+03*   | 2.57E+04    | 2.24E+02*   | 2.36E+04    | 1.03E+03*   |         |

Table 17. Radiative transition parameters for  $O_2^+ A^2\Pi_u - X^2\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $V'\backslash V''$ | 0        | 1        | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9         | 10        |
|--------------------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 16                 | .1970    | .2045    | .2125     | .2210     | .2301     | .2397     | .2499     | .2608     | .2725     | .2851     | .2985     |
|                    | 50761.4  | 48888.3  | 47048.0   | 45240.5   | 43465.7   | 41723.6   | 40014.0   | 38337.0   | 36692.6   | 35080.7   | 33501.5   |
|                    | 1.71E-02 | 2.99E-02 | 4.97E-03  | 8.10E-03  | 1.54E-02  | 9.05E-05  | 1.54E-02  | 2.72E-03  | 9.60E-03  | 8.69E-03  | 3.60E-03  |
|                    | 1.1644   | 1.1775   | 1.1882    | 1.2050    | 1.2147    | 1.2684    | 1.2421    | 1.2473    | 1.2714    | 1.2797    | 1.3041    |
|                    | 1.72E-01 | 1.75E-01 | 1.78E-01  | 1.82E-01  | 1.84E-01  | 2.00E-01  | 1.92E-01  | 1.93E-01  | 2.01E-01  | 2.03E-01  | 2.11E-01  |
|                    | 1.34E+05 | 2.17E+05 | 3.30E+04  | 5.02E+04  | 8.72E+04  | 5.31E+02  | 7.35E+04  | 1.16E+04  | 3.87E+04  | 3.14E+04  | 1.23E+04  |
|                    | 1.35E+05 | 2.17E+05 | 3.27E+04* | 5.06E+04* | 8.69E+04  | 5.85E+02* | 7.36E+04  | 1.13E+04* | 3.90E+04* | 3.10E+04* | 1.26E+04* |
| 17                 | .1953    | .2027    | .2106     | .2189     | .2278     | .2372     | .2472     | .2579     | .2693     | .2815     | .2946     |
|                    | 51202.0  | 49328.9  | 47488.6   | 45681.1   | 43906.3   | 42164.2   | 40454.6   | 38777.6   | 37133.2   | 35521.3   | 33942.1   |
|                    | 1.82E-02 | 2.70E-02 | 2.29E-03  | 1.06E-02  | 1.15E-02  | 1.37E-03  | 1.46E-02  | 3.34E-04  | 1.23E-02  | 3.64E-03  | 7.87E-03  |
|                    | 1.1614   | 1.1745   | 1.1847    | 1.2012    | 1.2110    | 1.2346    | 1.2379    | 1.2282    | 1.2662    | 1.2726    | 1.2965    |
|                    | 1.72E-01 | 1.74E-01 | 1.77E-01  | 1.81E-01  | 1.83E-01  | 1.90E-01  | 1.91E-01  | 1.88E-01  | 1.99E-01  | 2.01E-01  | 2.09E-01  |
|                    | 1.46E+05 | 2.00E+05 | 1.55E+04  | 6.69E+04  | 6.60E+04  | 7.49E+03  | 7.09E+04  | 1.39E+03  | 5.05E+04  | 1.33E+04  | 2.72E+04  |
|                    | 1.46E+05 | 2.00E+05 | 1.53E+04* | 6.72E+04  | 6.56E+04  | 7.68E+03* | 7.09E+04  | 1.29E+03* | 5.08E+04  | 1.30E+04* | 2.75E+04* |
| 18                 | .1937    | .2010    | .2088     | .2169     | .2256     | .2349     | .2447     | .2552     | .2663     | .2783     | .2911     |
|                    | 51616.3  | 49743.2  | 47902.9   | 46095.5   | 44320.7   | 42578.5   | 40868.9   | 39191.9   | 37547.5   | 35935.7   | 34356.4   |
|                    | 1.91E-02 | 2.40E-02 | 7.39E-04  | 1.23E-02  | 7.71E-03  | 3.45E-03  | 1.22E-02  | 1.44E-04  | 1.27E-02  | 7.03E-04  | 1.08E-02  |
|                    | 1.1585   | 1.1717   | 1.1810    | 1.1979    | 1.2074    | 1.2274    | 1.2340    | 1.2828    | 1.2617    | 1.2593    | 1.2909    |
|                    | 1.71E-01 | 1.74E-01 | 1.76E-01  | 1.80E-01  | 1.82E-01  | 1.88E-01  | 1.89E-01  | 2.04E-01  | 1.98E-01  | 1.97E-01  | 2.07E-01  |
|                    | 1.55E+05 | 1.81E+05 | 5.09E+03  | 7.89E+04  | 4.52E+04  | 1.90E+04  | 6.05E+04  | 7.32E+02  | 5.33E+04  | 2.56E+03  | 3.78E+04  |
|                    | 1.55E+05 | 1.80E+05 | 4.95E+03* | 7.92E+04  | 4.48E+04* | 1.93E+04* | 6.03E+04  | 7.99E+02* | 5.33E+04  | 2.42E+03* | 3.81E+04  |
| 19                 | .1923    | .1995    | .2071     | .2151     | .2237     | .2327     | .2424     | .2527     | .2636     | .2753     | .2878     |
|                    | 52004.5  | 50131.3  | 48291.1   | 46483.6   | 44708.8   | 42966.6   | 41257.1   | 39580.1   | 37935.6   | 36323.8   | 34744.5   |
|                    | 1.96E-02 | 2.09E-02 | 7.57E-05  | 1.31E-02  | 4.62E-03  | 5.57E-03  | 9.15E-03  | 1.37E-03  | 1.13E-02  | 1.94E-05  | 1.14E-02  |
|                    | 1.1558   | 1.1692   | 1.1742    | 1.1949    | 1.2039    | 1.2227    | 1.2302    | 1.2554    | 1.2575    | 1.3683    | 1.2861    |
|                    | 1.70E-01 | 1.73E-01 | 1.74E-01  | 1.79E-01  | 1.81E-01  | 1.86E-01  | 1.88E-01  | 1.96E-01  | 1.96E-01  | 2.37E-01  | 2.05E-01  |
|                    | 1.62E+05 | 1.60E+05 | 5.25E+02  | 8.55E+04  | 2.76E+04  | 3.11E+04  | 4.62E+04  | 6.59E+03  | 4.81E+04  | 1.05E+02  | 4.08E+04  |
|                    | 1.62E+05 | 1.60E+05 | 4.82E+02* | 8.57E+04  | 2.73E+04* | 3.14E+04* | 4.59E+04* | 6.78E+03* | 4.80E+04  | 1.30E+02* | 4.09E+04  |
| 20                 | .1910    | .1980    | .2055     | .2135     | .2219     | .2308     | .2403     | .2504     | .2611     | .2726     | .2848     |
|                    | 52366.5  | 50493.4  | 48653.1   | 46845.6   | 45070.8   | 43328.7   | 41619.1   | 39942.1   | 38297.7   | 36685.8   | 35106.6   |
|                    | 1.98E-02 | 1.78E-02 | 5.45E-05  | 1.31E-02  | 2.38E-03  | 7.24E-03  | 6.16E-03  | 3.16E-03  | 8.81E-03  | 9.15E-04  | 1.01E-02  |
|                    | 1.1533   | 1.1669   | 1.1846    | 1.1922    | 1.2003    | 1.2191    | 1.2264    | 1.2482    | 1.2534    | 1.2818    | 1.2817    |
|                    | 1.70E-01 | 1.73E-01 | 1.77E-01  | 1.79E-01  | 1.81E-01  | 1.85E-01  | 1.87E-01  | 1.94E-01  | 1.95E-01  | 2.04E-01  | 2.04E-01  |
|                    | 1.66E+05 | 1.39E+05 | 3.97E+02  | 8.68E+04  | 1.44E+04  | 4.10E+04  | 3.16E+04  | 1.53E+04  | 3.81E+04  | 3.81E+03  | 3.69E+04  |
|                    | 1.66E+05 | 1.38E+05 | 4.35E+02* | 8.69E+04  | 1.42E+04* | 4.13E+04* | 3.13E+04* | 1.55E+04* | 3.79E+04* | 3.96E+03* | 3.68E+04  |
| 21                 | .1897    | .1967    | .2041     | .2119     | .2202     | .2290     | .2384     | .2483     | .2588     | .2701     | .2822     |
|                    | 52702.0  | 50828.8  | 48988.6   | 47181.1   | 45406.3   | 43664.1   | 41954.6   | 40277.6   | 38633.1   | 37021.3   | 35442.0   |
|                    | 1.96E-02 | 1.49E-02 | 4.39E-04  | 1.24E-02  | 9.60E-04  | 8.21E-03  | 3.67E-03  | 4.81E-03  | 6.09E-03  | 2.49E-03  | 7.77E-03  |
|                    | 1.1509   | 1.1647   | 1.1777    | 1.1897    | 1.1959    | 1.2160    | 1.2226    | 1.2436    | 1.2495    | 1.2728    | 1.2775    |
|                    | 1.69E-01 | 1.72E-01 | 1.75E-01  | 1.78E-01  | 1.79E-01  | 1.85E-01  | 1.86E-01  | 1.92E-01  | 1.94E-01  | 2.01E-01  | 2.03E-01  |
|                    | 1.67E+05 | 1.18E+05 | 3.21E+03  | 8.34E+04  | 5.86E+03  | 4.72E+04  | 1.90E+04  | 2.35E+04  | 2.68E+04  | 1.04E+04  | 2.88E+04  |
|                    | 1.67E+05 | 1.18E+05 | 3.31E+03* | 8.34E+04  | 5.71E+03* | 4.74E+04* | 1.88E+04* | 2.38E+04* | 2.65E+04* | 1.06E+04* | 2.86E+04* |

Table 17. Radiative transition parameters for  $O_2^+ A^3\Pi_u - X^3\Pi_g$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \backslash V''$ | 11          | 12        | 13          | 14          | 15          | 16          | 17          | 18          | 19          | 20          | 21          |
|---------------------|-------------|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 16                  | .3129       | .3285     | .3453       | .3635       | .3832       | .4046       | .4280       | .4535       | .4815       | .5123       | .5462       |
|                     | 31954.9     | 30441.0   | 28959.9     | 27511.7     | 26096.5     | 24714.5     | 23365.7     | 22050.4     | 20768.8     | 19521.0     | 18307.2     |
|                     | 1.34E-02    | 3.36E-04  | 1.51E-02    | 4.97E-04    | 1.40E-02    | 3.47E-03    | 1.08E-02    | 8.13E-03    | 6.86E-03    | 1.34E-02    | 3.17E-03    |
|                     | 1.3111      | 1.3564    | 1.3435      | 1.3308      | 1.3775      | 1.3809      | 1.4139      | 1.4204      | 1.4542      | 1.4601      | 1.5019      |
|                     | 2.14E-01    | 2.31E-01  | 2.26E-01    | 2.21E-01    | 2.41E-01    | 2.42E-01    | 2.57E-01    | 2.61E-01    | 2.78E-01    | 2.82E-01    | 3.06E-01    |
|                     | 4.06E+04    | 1.03E+03  | 3.81E+04    | ( 1.03E+03) | 2.91E+04    | 6.22E+03    | 1.86E+04    | 1.20E+04    | 9.65E+03    | 1.60E+04    | 3.70E+03    |
|                     | 4.03E+04    | 1.13E+03* | 3.81E+04    | 9.16E+02*   | 2.93E+04    | 5.97E+03*   | 1.88E+04    | 1.17E+04*   | 9.94E+03*   | 1.57E+04    | 3.91E+03*   |
| 17                  | .3087       | .3238     | .3401       | .3578       | .3768       | .3975       | .4201       | .4446       | .4715       | .5010       | .5334       |
|                     | 32395.5     | 30881.6   | 29400.5     | 27952.3     | 26537.1     | 25155.1     | 23806.3     | 22491.0     | 21209.4     | 19961.6     | 18747.9     |
|                     | 8.06E-03    | 3.65E-03  | 1.18E-02    | 9.02E-04    | 1.40E-02    | 6.26E-11    | 1.48E-02    | 8.03E-04    | 1.42E-02    | 2.98E-03    | 1.27E-02    |
|                     | 1.3047      | 1.3303    | 1.3367      | 1.3741      | 1.3697      | 92.5600     | 1.4044      | 1.3932      | 1.4415      | 1.4421      | 1.4816      |
|                     | 2.12E-01    | 2.21E-01  | 2.24E-01    | 2.39E-01    | 2.37E-01    | 1.20E-01    | 2.53E-01    | 2.48E-01    | 2.72E-01    | 2.72E-01    | 2.94E-01    |
|                     | 2.49E+04    | 1.07E+04  | 3.03E+04    | 2.28E+03    | 2.99E+04    | ( 2.91E-05) | 2.58E+04    | ( 1.14E+03) | 2.02E+04    | 3.55E+03    | 1.46E+04    |
|                     | 2.46E+04*   | 1.09E+04* | 3.01E+04    | 2.43E+03*   | 2.98E+04    | 1.30E+01*   | 2.59E+04    | 1.01E+03*   | 2.04E+04    | 3.35E+03*   | 1.48E+04    |
| 18                  | .3048       | .3195     | .3354       | .3525       | .3710       | .3911       | .4129       | .4366       | .4625       | .4908       | .5219       |
|                     | 32809.8     | 31295.9   | 29814.8     | 28366.6     | 26951.5     | 25569.4     | 24220.7     | 22905.4     | 21623.7     | 20375.9     | 19162.2     |
|                     | 3.23E-03    | 7.76E-03  | 6.39E-03    | 4.82E-03    | 9.43E-03    | 2.48E-03    | 1.20E-02    | 9.35E-04    | 1.39E-02    | 1.50E-04    | 1.54E-02    |
|                     | 1.2972      | 1.3223    | 1.3297      | 1.3564      | 1.3623      | 1.3943      | 1.3961      | 1.4401      | 1.4319      | 1.5236      | 1.4700      |
|                     | 2.09E-01    | 2.18E-01  | 2.21E-01    | 2.31E-01    | 2.34E-01    | 2.48E-01    | 2.49E-01    | 2.71E-01    | 2.67E-01    | 3.20E-01    | 2.87E-01    |
|                     | 1.01E+04    | 2.29E+04  | 1.67E+04    | 1.19E+04    | 2.05E+04    | 5.18E+03    | 2.14E+04    | 1.67E+03    | 2.03E+04    | ( 2.64E+02) | 1.81E+04    |
|                     | 9.84E+03*   | 2.32E+04* | 1.64E+04*   | 1.22E+04*   | 2.02E+04*   | 5.39E+03*   | 2.12E+04    | 1.81E+03*   | 2.02E+04    | 3.18E+02*   | 1.81E+04    |
| 19                  | .3012       | .3156     | .3311       | .3478       | .3658       | .3852       | .4064       | .4293       | .4543       | .4816       | .5115       |
|                     | 33197.9     | 31684.1   | 30203.0     | 28754.8     | 27339.6     | 25957.6     | 24608.8     | 23293.5     | 22011.9     | 20764.1     | 19550.3     |
|                     | 5.23E-04    | 1.03E-02  | 2.05E-03    | 8.61E-03    | 4.06E-03    | 6.92E-03    | 6.17E-03    | 5.44E-03    | 8.21E-03    | 4.25E-03    | 1.01E-02    |
|                     | 1.2818      | 1.3165    | 1.3204      | 1.3486      | 1.3537      | 1.3824      | 1.3872      | 1.4180      | 1.4224      | 1.4563      | 1.4593      |
|                     | 2.04E-01    | 2.16E-01  | 2.17E-01    | 2.28E-01    | 2.30E-01    | 2.43E-01    | 2.45E-01    | 2.59E-01    | 2.62E-01    | 2.80E-01    | 2.81E-01    |
|                     | 1.61E+03    | 3.08E+04  | 5.42E+03    | 2.16E+04    | 8.91E+03    | 1.44E+04    | 1.12E+04    | 9.38E+03    | 1.22E+04    | 6.02E+03    | 1.21E+04    |
|                     | 1.49E+03*   | 3.10E+04  | 5.21E+03*   | 2.18E+04*   | 8.66E+03*   | 1.47E+04*   | 1.09E+04*   | 9.62E+03*   | 1.19E+04*   | 6.24E+03*   | 1.19E+04    |
| 20                  | .2980       | .3121     | .3272       | .3434       | .3610       | .3799       | .4005       | .4227       | .4469       | .4733       | .5022       |
|                     | 33560.0     | 32046.1   | 30565.0     | 29116.8     | 27701.6     | 26319.6     | 24970.8     | 23655.5     | 22373.9     | 21126.1     | 19912.3     |
|                     | 6.25E-05    | 1.04E-02  | 1.22E-04    | 1.02E-02    | 7.26E-04    | 9.76E-03    | 1.60E-03    | 9.37E-03    | 2.52E-03    | 9.14E-03    | 3.38E-03    |
|                     | 1.3495      | 1.3115    | 1.2850      | 1.3427      | 1.3371      | 1.3751      | 1.3735      | 1.4088      | 1.4093      | 1.4444      | 1.4458      |
|                     | 2.29E-01    | 2.14E-01  | 2.05E-01    | 2.26E-01    | 2.24E-01    | 2.39E-01    | 2.39E-01    | 2.55E-01    | 2.55E-01    | 2.73E-01    | 2.74E-01    |
|                     | ( 2.50E+02) | 3.10E+04  | ( 2.07E+02) | 2.60E+04    | 1.57E+03    | 2.07E+04    | 2.87E+03    | 1.63E+04    | 3.73E+03    | 1.30E+04    | 4.05E+03    |
|                     | 2.94E+02*   | 3.19E+04  | 2.45E+02*   | 2.61E+04    | 1.45E+03*   | 2.08E+04*   | 2.71E+03*   | 1.65E+04*   | 3.55E+03*   | 1.32E+04*   | 3.87E+03*   |
| 21                  | .2950       | .3088     | .3236       | .3395       | .3567       | .3752       | .3952       | .4168       | .4403       | .4659       | .4939       |
|                     | 33895.4     | 32381.6   | 30900.5     | 29452.3     | 28037.1     | 26655.1     | 25306.3     | 23991.0     | 22709.4     | 21461.6     | 20247.8     |
|                     | 1.09E-03    | 8.79E-03  | 3.48E-04    | 9.38E-03    | 4.65E-05    | 9.81E-03    | 5.21E-06    | 1.02E-02    | 7.20E-05    | 1.07E-02    | 1.39E-04    |
|                     | 1.3051      | 1.3069    | 1.3458      | 1.3375      | 1.4302      | 1.3691      | 1.1067      | 1.4017      | 1.3335      | 1.4361      | 1.3850      |
|                     | 2.12E-01    | 2.12E-01  | 2.27E-01    | 2.24E-01    | 2.66E-01    | 2.37E-01    | 1.61E-01    | 2.52E-01    | 2.22E-01    | 2.69E-01    | 2.44E-01    |
|                     | 3.86E+03    | 2.73E+04  | 1.07E+03    | 2.44E+04    | ( 1.47E+02) | 2.11E+04    | ( 4.42E+00) | 1.81E+04    | ( 8.45E+01) | 1.55E+04    | ( 1.39E+02) |
|                     | 4.02E+03*   | 2.72E+04* | 1.16E+03*   | 2.43E+04*   | 1.80E+02*   | 2.11E+04*   | 4.80E-04*   | 1.81E+04    | 5.50E+01*   | 1.56E+04    | 9.99E+01*   |

\*The Einstein coefficients for this band may have limited accuracy, since the Franck-Condon factor is less than 0.01 (see text).

Table 18. Radiative transition parameters for  $O_2^+ b \ ^4\Sigma_g^- - a \ ^4\Pi_u$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ .

| $v' \backslash v''$ | 0           | 1           | 2           | 3        | 4           | 5         | 6           | 7         | 8         | 9         | 10      |
|---------------------|-------------|-------------|-------------|----------|-------------|-----------|-------------|-----------|-----------|-----------|---------|
| 0                   | .6000       | .6389       | .6822       | .7308    | .7855       | .8475     | .9183       | 1.0000    | 1.0950    | 1.2067    | 1.3400  |
|                     | 16666.4     | 15651.7     | 14657.4     | 13683.9  | 12731.2     | 11799.6   | 10889.2     | 10000.2   | 9132.6    | 8286.8    | 7462.8  |
| 2.65E-01            | 2.92E-01    | 2.06E-01    | 1.19E-01    | 6.19E-02 | 3.01E-02    | 1.41E-02  | 6.50E-03    | 2.96E-03  | 1.34E-03  | 6.15E-04  |         |
| 1.3375              | 1.3013      | 1.2716      | 1.2460      | 1.2235   | 1.2034      | 1.1851    | 1.1684      | 1.1531    | 1.1390    | 1.1260    |         |
| 2.05E-01            | 2.19E-01    | 2.29E-01    | 2.38E-01    | 2.45E-01 | 2.51E-01    | 2.56E-01  | 2.61E-01    | 2.65E-01  | 2.68E-01  | 2.71E-01  |         |
| 2.09E+05            | 2.17E+05    | 1.38E+05    | 6.99E+04    | 3.10E+04 | 1.26E+04    | 4.86E+03  | 1.79E+03    | 6.40E+02  | 2.23E+02  | 7.62E+01  |         |
| 2.08E+05            | 2.16E+05    | 1.38E+05    | 7.01E+04    | 3.12E+04 | 1.27E+04    | 4.91E+03  | 1.81E+03*   | 6.48E+02* | 2.26E+02* | 7.73E+01* |         |
| 1                   | .5609       | .5947       | .6321       | .6736    | .7197       | .7715     | .8297       | .8958     | .9713     | 1.0583    | 1.1594  |
|                     | 17829.1     | 16814.4     | 15820.2     | 14846.6  | 13893.9     | 12962.3   | 12051.9     | 11162.9   | 10295.4   | 9449.5    | 8625.5  |
| 4.28E-01            | 2.34E-02    | 3.96E-02    | 1.20E-01    | 1.33E-01 | 1.03E-01    | 6.73E-02  | 3.96E-02    | 2.18E-02  | 1.16E-02  | 6.04E-03  |         |
| 1.3791              | 1.3083      | 1.3220      | 1.2819      | 1.2540   | 1.2305      | 1.2099    | 1.1914      | 1.1747    | 1.1594    | 1.1453    |         |
| 1.89E-01            | 2.16E-01    | 2.11E-01    | 2.25E-01    | 2.35E-01 | 2.43E-01    | 2.49E-01  | 2.55E-01    | 2.59E-01  | 2.63E-01  | 2.67E-01  |         |
| 3.52E+05            | 2.10E+04    | 2.83E+04    | 8.10E+04    | 7.98E+04 | 5.37E+04    | 2.96E+04  | 1.45E+04    | 6.49E+03  | 2.75E+03  | 1.12E+03  |         |
| 3.52E+05            | 2.13E+04    | 2.78E+04    | 8.05E+04    | 7.97E+04 | 5.38E+04    | 2.98E+04  | 1.46E+04    | 6.55E+03  | 2.78E+03  | 1.13E+03* |         |
| 2                   | .5275       | .5573       | .5900       | .6260    | .6657       | .7097     | .7587       | .8136     | .8754     | .9454     | 1.0252  |
|                     | 18957.6     | 17942.9     | 16948.6     | 15975.1  | 15022.4     | 14090.8   | 13180.4     | 12291.3   | 11423.8   | 10578.0   | 9753.9  |
| 2.44E-01            | 1.77E-01    | 1.40E-01    | 7.27E-03    | 2.24E-02 | 7.38E-02    | 9.29E-02  | 8.23E-02    | 6.06E-02  | 4.00E-02  | 2.47E-02  |         |
| 1.4296              | 1.3980      | 1.3361      | 1.2629      | 1.3022   | 1.2638      | 1.2382    | 1.2168      | 1.1979    | 1.1810    | 1.1657    |         |
| 1.70E-01            | 1.82E-01    | 2.06E-01    | 2.32E-01    | 2.18E-01 | 2.32E-01    | 2.40E-01  | 2.47E-01    | 2.53E-01  | 2.58E-01  | 2.62E-01  |         |
| 1.94E+05            | 1.37E+05    | 1.17E+05    | 6.47E+03    | 1.47E+04 | 4.49E+04    | 4.98E+04  | 3.78E+04    | 2.34E+04  | 1.27E+04  | 6.35E+03  |         |
| 1.95E+05            | 1.37E+05    | 1.17E+05    | 6.72E+03*   | 1.43E+04 | 4.45E+04    | 4.96E+04  | 3.78E+04    | 2.35E+04  | 1.28E+04  | 6.40E+03  |         |
| 3                   | .4987       | .5253       | .5542       | .5858    | .6205       | .6585     | .7005       | .7471     | .7988     | .8567     | .9218   |
|                     | 20051.8     | 19037.0     | 18042.8     | 17069.3  | 16116.6     | 15185.0   | 14274.6     | 13385.5   | 12518.0   | 11672.2   | 10848.1 |
| 5.81E-02            | 3.48E-01    | 2.46E-02    | 1.42E-01    | 5.98E-02 | 8.45E-04    | 1.95E-02  | 5.43E-02    | 6.98E-02  | 6.56E-02  | 5.20E-02  |         |
| 1.4965              | 1.4425      | 1.4514      | 1.3490      | 1.3018   | 1.1661      | 1.2810    | 1.2475      | 1.2243    | 1.2047    | 1.1875    |         |
| 1.44E-01            | 1.65E-01    | 1.61E-01    | 2.01E-01    | 2.18E-01 | 2.62E-01    | 2.26E-01  | 2.37E-01    | 2.45E-01  | 2.51E-01  | 2.56E-01  |         |
| 3.94E+04            | 2.64E+05    | 1.52E+04    | 1.15E+05    | 4.84E+04 | ( 8.21E+02) | 1.17E+04  | 2.97E+04    | 3.32E+04  | 2.66E+04  | 1.76E+04  |         |
| 3.92E+04            | 2.65E+05    | 1.51E+04    | 1.15E+05    | 4.88E+04 | 9.43E+02*   | 1.15E+04  | 2.94E+04    | 3.31E+04  | 2.66E+04  | 1.76E+04  |         |
| 4                   | .4737       | .4976       | .5235       | .5516    | .5822       | .6156     | .6521       | .6923     | .7365     | .7854     | .8398   |
|                     | 21111.7     | 20097.0     | 19102.7     | 18129.2  | 17176.5     | 16244.9   | 15334.5     | 14445.4   | 13577.9   | 12732.1   | 11908.0 |
| 4.97E-03            | 1.43E-01    | 3.32E-01    | 2.23E-03    | 8.20E-02 | 9.02E-02    | 2.39E-02  | 1.56E-04    | 1.89E-02  | 4.33E-02  | 5.46E-02  |         |
| 1.6041              | 1.5093      | 1.4578      | 1.1443      | 1.3638   | 1.3140      | 1.2705    | 1.5118      | 1.2620    | 1.2331    | 1.2121    |         |
| 1.06E-01            | 1.39E-01    | 1.59E-01    | 2.67E-01    | 1.95E-01 | 2.14E-01    | 2.29E-01  | 1.38E-01    | 2.32E-01  | 2.42E-01  | 2.49E-01  |         |
| 2.12E+03            | 9.12E+04    | 2.36E+05    | 3.84E+03    | 6.41E+04 | 7.17E+04    | 1.84E+04  | ( 3.65E+01) | 1.03E+04  | 2.12E+04  | 2.31E+04  |         |
| 1.98E+03*           | 9.10E+04    | 2.38E+05    | 4.20E+03*   | 6.34E+04 | 7.17E+04    | 1.87E+04  | 2.39E+01*   | 1.01E+04  | 2.10E+04  | 2.30E+04  |         |
| 5                   | .4517       | .4734       | .4968       | .5221    | .5494       | .5790     | .6112       | .6464     | .6848     | .7269     | .7732   |
|                     | 22137.3     | 21122.5     | 20128.3     | 19154.8  | 18202.1     | 17270.5   | 16360.1     | 15471.0   | 14603.5   | 13757.7   | 12933.6 |
| 5.90E-05            | 1.60E-02    | 2.26E-01    | 2.66E-01    | 3.29E-02 | 2.89E-02    | 8.31E-02  | 5.01E-02    | 7.92E-03  | 1.68E-03  | 1.81E-02  |         |
| 1.9562              | 1.6230      | 1.5229      | 1.4767      | 1.3295   | 1.3881      | 1.3244    | 1.2848      | 1.2371    | 1.3160    | 1.2459    |         |
| 2.60E-02            | 9.97E-02    | 1.34E-01    | 1.52E-01    | 2.08E-01 | 1.86E-01    | 2.10E-01  | 2.24E-01    | 2.41E-01  | 2.13E-01  | 2.38E-01  |         |
| 1.75E+00            | 6.06E+03    | 1.35E+05    | 1.74E+05    | 3.48E+04 | 2.08E+04    | 6.50E+04  | 3.78E+04    | 5.79E+03  | 8.04E+02  | 8.99E+03  |         |
| 1.81E+00*           | 5.61E+03    | 1.35E+05    | 1.76E+05    | 3.46E+04 | 2.04E+04    | 6.47E+04  | 3.81E+04    | 6.02E+03* | 7.35E+02* | 8.79E+03  |         |
| 6                   | .4324       | .4522       | .4735       | .4964    | .5210       | .5476     | .5763       | .6075     | .6412     | .6780     | .7181   |
|                     | 23128.5     | 22113.8     | 21119.5     | 20146.0  | 19193.3     | 18261.7   | 17351.3     | 16462.2   | 15594.7   | 14748.9   | 13924.8 |
| 3.10E-06            | 1.51E-04    | 3.11E-02    | 2.96E-01    | 1.95E-01 | 6.62E-02    | 3.64E-03  | 5.72E-02    | 6.11E-02  | 2.50E-02  | 1.82E-03  |         |
| 1.2975              | 2.0951      | 1.6435      | 1.5375      | 1.5013   | 1.3538      | 1.4702    | 1.3356      | 1.2942    | 1.2586    | 1.1874    |         |
| 2.20E-01            | 1.27E-02    | 9.32E-02    | 1.29E-01    | 1.42E-01 | 1.99E-01    | 1.54E-01  | 2.06E-01    | 2.21E-01  | 2.34E-01  | 2.56E-01  |         |
| ( 7.52E+00)         | ( 1.06E+00) | 1.03E+04    | 1.63E+05    | 1.13E+05 | 6.47E+04    | 1.83E+03  | 4.38E+04    | 4.59E+04  | 1.77E+04  | 1.30E+03  |         |
| 6.00E+00*           | 3.57E+01*   | 9.42E+03    | 1.64E+05    | 1.16E+05 | 6.38E+04    | 1.69E+03* | 4.33E+04    | 4.59E+04  | 1.80E+04  | 1.42E+03* |         |
| 7                   | .4152       | .4335       | .4530       | .4739    | .4963       | .5203     | .5462       | .5741     | .6042     | .6367     | .6720   |
|                     | 24085.2     | 23070.5     | 22076.3     | 21102.7  | 20150.1     | 19218.4   | 18308.0     | 17419.0   | 16551.5   | 15705.6   | 14881.6 |
| 1.14E-07            | 2.33E-05    | 1.77E-04    | 4.75E-02    | 3.50E-01 | 1.39E-01    | 8.47E-02  | 8.91E-04    | 3.05E-02  | 5.66E-02  | 3.85E-02  |         |
| 2.0022              | 1.4032      | 2.3657      | 1.6660      | 1.5532   | 1.5337      | 1.3633    | 1.1262      | 1.3502    | 1.3026    | 1.2689    |         |
| 2.07E-02            | 1.80E-01    | 2.38E-03    | 8.64E-02    | 1.23E-01 | 1.30E-01    | 1.95E-01  | 2.71E-01    | 2.00E-01  | 2.18E-01  | 2.30E-01  |         |
| ( 2.76E-03)         | ( 3.75E+01) | ( 4.38E-02) | ( 1.35E+04) | 1.77E+05 | 6.79E+04    | 8.04E+04  | ( 1.40E+03) | 2.25E+04  | 4.23E+04  | 2.72E+04  |         |
| 3.50E-02*           | 2.89E+01*   | 2.08E+02*   | 1.21E+04    | 1.79E+05 | 7.03E+04    | 7.87E+04  | 1.70E+03*   | 2.20E+04  | 4.20E+04  | 2.74E+04  |         |

Table 18. Radiative transition parameters for  $O_2^+ b^4\Sigma_g^- - a^4\Pi_u$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \setminus V''$ | 11               | 12               | 13               | 14               | 15               | 16               | 17               | 18               | 19               | 20               | 21                 |
|--------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|--------------------|
| 0                  | 1.5014<br>6660.7 | 1.7005<br>5880.6 | 1.9521<br>5122.8 | 2.2793<br>4387.3 | 2.7216<br>3674.4 | 3.3511<br>2984.1 | 4.3164<br>2316.7 | 5.9790<br>1672.5 | 9.5088<br>1051.7 | 22.0063<br>454.4 | -84.2112<br>-118.7 |
|                    | 2.84E-04         | 1.34E-04         | 6.42E-05         | 3.16E-05         | 1.41E-05         | 8.47E-06         | 4.44E-06         | 2.45E-06         | 1.58E-06         | 9.85E-07         | 6.40E-07           |
|                    | 1.1141           | 1.1031           | 1.0933           | 1.0845           | 1.0769           | 1.0705           | 1.0654           | 1.0616           | 1.0590           | 1.0575           | 1.0570             |
|                    | 2.74E-01         | 2.76E-01         | 2.78E-01         | 2.79E-01         | 2.81E-01         | 2.82E-01         | 2.83E-01         | 2.83E-01         | 2.83E-01         | 2.83E-01         | 2.83E-01           |
|                    | 2.55E+01         | 8.38E+00         | 2.70E+00         | 8.44E-01         | 2.54E-01         | 7.23E-02         | 1.86E-02         | 4.02E-03         | 5.97E-04         | 3.01E-05         | -1.74E-07          |
|                    | 2.59E+01*        | 8.53E+00*        | 2.75E+00*        | 8.60E-01*        | 2.59E-01*        | 7.36E-02*        | 1.90E-02*        | 4.08E-03*        | 6.06E-04*        | 3.05E-05*        | -1.76E-07*         |
| 1                  | 1.2782<br>7823.4 | 1.4198<br>7043.3 | 1.5910<br>6285.5 | 1.8018<br>5550.0 | 2.0674<br>4837.1 | 2.4115<br>4146.8 | 2.8740<br>3479.5 | 3.5270<br>2835.2 | 4.5159<br>2214.4 | 6.1838<br>1617.1 | 9.5788<br>1044.0   |
|                    | 3.11E-03         | 1.60E-03         | 8.27E-04         | 4.34E-04         | 2.32E-04         | 1.27E-04         | 7.17E-05         | 4.18E-05         | 2.52E-05         | 1.58E-05         | 1.02E-05           |
|                    | 1.1324           | 1.1206           | 1.1098           | 1.1001           | 1.0915           | 1.0839           | 1.0776           | 1.0723           | 1.0683           | 1.0653           | 1.0633             |
|                    | 2.70E-01         | 2.72E-01         | 2.75E-01         | 2.76E-01         | 2.78E-01         | 2.79E-01         | 2.80E-01         | 2.81E-01         | 2.82E-01         | 2.82E-01         | 2.83E-01           |
|                    | 4.39E+02         | 1.68E+02         | 6.27E+01         | 2.30E+01         | 8.22E+00         | 2.87E+00         | 9.62E-01         | 3.05E-01         | 8.81E-02         | 2.16E-02         | 3.77E-03           |
|                    | 4.45E+02*        | 1.70E+02*        | 6.37E+01*        | 2.34E+01*        | 8.37E+00*        | 2.92E+00*        | 9.79E-01*        | 3.10E-01*        | 8.96E-02*        | 2.19E-02*        | 3.82E-03*          |
| 2                  | 1.1171<br>8951.8 | 1.2237<br>8171.8 | 1.3488<br>7414.0 | 1.4973<br>6678.5 | 1.6763<br>5965.5 | 1.8956<br>5275.3 | 2.1702<br>4607.9 | 2.5229<br>3963.7 | 2.9915<br>3342.8 | 3.6422<br>2745.6 | 4.6031<br>2172.4   |
|                    | 1.46E-02         | 8.38E-03         | 4.76E-03         | 2.70E-03         | 1.54E-03         | 8.89E-04         | 5.23E-04         | 3.14E-04         | 1.94E-04         | 1.23E-04         | 8.08E-05           |
|                    | 1.1517           | 1.1388           | 1.1272           | 1.1165           | 1.1070           | 1.0985           | 1.0910           | 1.0846           | 1.0793           | 1.0750           | 1.0717             |
|                    | 2.65E-01         | 2.68E-01         | 2.71E-01         | 2.73E-01         | 2.75E-01         | 2.77E-01         | 2.78E-01         | 2.79E-01         | 2.80E-01         | 2.81E-01         | 2.81E-01           |
|                    | 2.98E+03         | 1.33E+03         | 5.78E+02         | 2.43E+02         | 1.00E+02         | 4.05E+01         | 1.60E+01         | 6.19E+00         | 2.31E+00         | 8.16E-01         | 2.66E-01           |
|                    | 3.01E+03         | 1.35E+03*        | 5.85E+02*        | 2.47E+02*        | 1.02E+02*        | 4.12E+01*        | 1.63E+01*        | 6.28E+00*        | 2.34E+00*        | 8.28E-01*        | 2.69E-01*          |
| 3                  | .9954<br>10046.0 | 1.0792<br>9266.0 | 1.1753<br>8508.2 | 1.2866<br>7772.7 | 1.4165<br>7059.7 | 1.5700<br>6369.5 | 1.7537<br>5702.1 | 1.9771<br>5057.9 | 2.2538<br>4437.0 | 2.6043<br>3839.8 | 3.0613<br>3266.6   |
|                    | 3.71E-02         | 2.48E-02         | 1.59E-02         | 9.97E-03         | 6.17E-03         | 3.80E-03         | 2.36E-03         | 1.48E-03         | 9.47E-04         | 6.17E-04         | 4.11E-04           |
|                    | 1.1721           | 1.1581           | 1.1454           | 1.1338           | 1.1233           | 1.1139           | 1.1055           | 1.0982           | 1.0918           | 1.0864           | 1.0819             |
|                    | 2.60E-01         | 2.64E-01         | 2.67E-01         | 2.69E-01         | 2.72E-01         | 2.74E-01         | 2.75E-01         | 2.77E-01         | 2.78E-01         | 2.79E-01         | 2.80E-01           |
|                    | 1.03E+04         | 5.56E+03         | 2.83E+03         | 1.38E+03         | 6.49E+02         | 2.99E+02         | 1.35E+02         | 5.96E+01         | 2.59E+01         | 1.10E+01         | 4.55E+00           |
|                    | 1.04E+04         | 5.61E+03         | 2.86E+03         | 1.39E+03*        | 6.57E+02*        | 3.03E+02*        | 1.36E+02*        | 6.04E+01*        | 2.63E+01*        | 1.12E+01*        | 4.61E+00*          |
| 4                  | .9004<br>11105.9 | .9684<br>10325.9 | 1.0451<br>9568.1 | 1.1322<br>8832.6 | 1.2316<br>8119.6 | 1.3460<br>7429.4 | 1.4788<br>6762.0 | 1.6346<br>6117.8 | 1.8192<br>5496.9 | 2.0409<br>4899.7 | 2.3113<br>4326.5   |
|                    | 5.29E-02         | 4.40E-02         | 3.33E-02         | 2.37E-02         | 1.63E-02         | 1.10E-02         | 7.30E-03         | 4.85E-03         | 3.24E-03         | 2.19E-03         | 1.50E-03           |
|                    | 1.1944           | 1.1788           | 1.1647           | 1.1521           | 1.1406           | 1.1303           | 1.1210           | 1.1127           | 1.1054           | 1.0990           | 1.0936             |
|                    | 2.54E-01         | 2.58E-01         | 2.62E-01         | 2.65E-01         | 2.68E-01         | 2.70E-01         | 2.72E-01         | 2.74E-01         | 2.75E-01         | 2.77E-01         | 2.78E-01           |
|                    | 1.89E+04         | 1.31E+04         | 8.11E+03         | 4.66E+03         | 2.54E+03         | 1.33E+03         | 6.78E+02         | 3.38E+02         | 1.66E+02         | 7.99E+01         | 3.80E+01           |
|                    | 1.89E+04         | 1.31E+04         | 8.15E+03         | 4.70E+03         | 2.56E+03         | 1.34E+03         | 6.86E+02*        | 3.42E+02*        | 1.68E+02*        | 8.10E+01*        | 3.85E+01*          |
| 5                  | .8243<br>12131.5 | .8809<br>11351.5 | .9440<br>10593.7 | 1.0144<br>9858.2 | 1.0935<br>9145.2 | 1.1827<br>8455.0 | 1.2841<br>7787.6 | 1.3999<br>7143.4 | 1.5331<br>6522.5 | 1.6877<br>5925.3 | 1.8684<br>5352.1   |
|                    | 3.53E-02         | 4.35E-02         | 4.27E-02         | 3.68E-02         | 2.92E-02         | 2.20E-02         | 1.61E-02         | 1.15E-02         | 8.16E-03         | 5.79E-03         | 4.13E-03           |
|                    | 1.2209           | 1.2019           | 1.1859           | 1.1717           | 1.1590           | 1.1476           | 1.1374           | 1.1282           | 1.1200           | 1.1127           | 1.1064             |
|                    | 2.46E-01         | 2.52E-01         | 2.56E-01         | 2.60E-01         | 2.63E-01         | 2.66E-01         | 2.69E-01         | 2.71E-01         | 2.73E-01         | 2.74E-01         | 2.75E-01           |
|                    | 1.54E+04         | 1.63E+04         | 1.35E+04         | 9.67E+03         | 6.29E+03         | 3.82E+03         | 2.22E+03         | 1.24E+03         | 6.82E+02         | 3.67E+02         | 1.94E+02           |
|                    | 1.53E+04         | 1.62E+04         | 1.35E+04         | 9.69E+03         | 6.32E+03         | 3.85E+03         | 2.24E+03         | 1.26E+03         | 6.89E+02*        | 3.71E+02*        | 1.97E+02*          |
| 6                  | .7620<br>13122.7 | .8102<br>12342.7 | .8632<br>11584.9 | .9217<br>10849.4 | .9865<br>10136.4 | 1.0586<br>9446.2 | 1.1391<br>8778.8 | 1.2293<br>8134.6 | 1.3309<br>7513.7 | 1.4458<br>6916.5 | 1.5765<br>6343.3   |
|                    | 3.39E-03         | 1.67E-02         | 2.87E-02         | 3.45E-02         | 3.43E-02         | 3.05E-02         | 2.53E-02         | 2.00E-02         | 1.54E-02         | 1.16E-02         | 8.74E-03           |
|                    | 1.2776           | 1.2330           | 1.2108           | 1.1937           | 1.1791           | 1.1663           | 1.1549           | 1.1447           | 1.1356           | 1.1274           | 1.1202             |
|                    | 2.27E-01         | 2.42E-01         | 2.49E-01         | 2.54E-01         | 2.58E-01         | 2.62E-01         | 2.64E-01         | 2.67E-01         | 2.69E-01         | 2.71E-01         | 2.72E-01           |
|                    | 1.60E+03         | 7.43E+03         | 1.12E+04         | 1.15E+04         | 9.65E+03         | 7.13E+03         | 4.84E+03         | 3.11E+03         | 1.91E+03         | 1.14E+03         | 6.71E+02           |
|                    | 1.51E+03*        | 7.28E+03         | 1.11E+04         | 1.15E+04         | 9.64E+03         | 7.14E+03         | 4.86E+03         | 3.13E+03         | 1.93E+03         | 1.15E+03         | 6.77E+02*          |
| 7                  | .7103<br>14079.5 | .7519<br>13299.4 | .7973<br>12541.6 | .8470<br>11806.1 | .9015<br>11093.2 | .9613<br>10402.9 | 1.0272<br>9735.6 | 1.0999<br>9091.4 | 1.1806<br>8470.5 | 1.2701<br>7873.2 | 1.3698<br>7300.1   |
|                    | 1.14E-02         | 1.41E-04         | 4.37E-03         | 1.44E-02         | 2.29E-02         | 2.70E-02         | 2.73E-02         | 2.49E-02         | 2.15E-02         | 1.77E-02         | 1.43E-02           |
|                    | 1.2327           | 1.0127           | 1.2579           | 1.2230           | 1.2031           | 1.1875           | 1.1743           | 1.1627           | 1.1524           | 1.1433           | 1.1352             |
|                    | 2.42E-01         | 2.88E-01         | 2.34E-01         | 2.45E-01         | 2.51E-01         | 2.56E-01         | 2.59E-01         | 2.62E-01         | 2.65E-01         | 2.67E-01         | 2.69E-01           |
|                    | 7.55E+03         | ( 1.11E+02)      | 1.91E+03         | 5.77E+03         | 7.98E+03         | 8.06E+03         | 6.86E+03         | 5.23E+03         | 3.71E+03         | 2.51E+03         | 1.63E+03           |
|                    | 7.76E+03         | 1.63E+02*        | 1.82E+03*        | 5.65E+03         | 7.89E+03         | 8.02E+03         | 6.85E+03         | 5.24E+03         | 3.73E+03         | 2.52E+03         | 1.64E+03           |

Table 18. Radiative transition parameters for  $O_2^+ b \ ^4\Sigma_g^- - a \ ^4\Pi_u$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_v^* R_e(r) \psi_{v''} dr$ . — Continued

| $V' \backslash V''$ | 0   | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10   |
|---------------------|---|--|--|--|--|--|--|--|--|--|--|
| 8                   | .3999<br>25007.4<br>1.48E-08<br>1.3868<br>1.86E-01<br>( 3.24E-02)<br>2.37E-02*  | .4168<br>23992.7<br>3.28E-07<br>9.09E-05<br>2.3385<br>2.86E-03<br>1.48E-01<br>( 1.50E-04)<br>7.34E-01* | .4348<br>22998.4<br>8.15E-05<br>3.2179<br>1.6910<br>1.21E-06<br>5.15E-09<br>7.32E+01*            | .4540<br>22024.9<br>6.23E-02<br>1.5700<br>1.5761<br>7.92E-06<br>1.48E+04<br>7.13E+02*            | .4746<br>21072.2<br>3.93E-01<br>1.00E-01<br>1.5761<br>1.17E-01<br>1.15E-01<br>1.80E+05<br>1.29E+04 | .4965<br>20140.6<br>8.77E-02<br>8.77E-02<br>1.3659<br>1.94E-01<br>1.94E-01<br>3.84E+04<br>1.83E+05 | .5200<br>19230.2<br>9.55E-03<br>1.18E-02<br>1.2967<br>2.20E-01<br>2.20E-01<br>8.28E+04<br>4.06E+04 | .5452<br>18341.1<br>1.3750<br>1.3750<br>1.2967<br>1.91E-01<br>1.91E-01<br>8.03E+04<br>8.03E+04   | .5723<br>17473.6<br>1.3750<br>1.3750<br>1.2967<br>2.01E+03<br>2.01E+03<br>7.73E+03<br>7.73E+03       | .6014<br>16627.8<br>4.36E-02<br>4.36E-02<br>1.3750<br>2.15E-01<br>2.15E-01<br>8.01E+03<br>3.22E+04   | .6328<br>15803.8<br>4.36E-02<br>4.36E-02<br>1.3750<br>2.15E-01<br>2.15E-01<br>3.22E+04<br>3.18E+04   |
| 9                   | .3862<br>25894.9<br>3.89E-12<br>8.5735<br>0.00E+00<br>( 0.00E+00)<br>2.21E-03*  | .4019<br>24880.1<br>1.43E-07<br>1.5064<br>1.40E-01<br>2.89E-09<br>1.20E-01<br>0.00E+00<br>1.11E-01*    | .4187<br>23885.9<br>1.88E-07<br>3.7136<br>1.5616<br>-9.1323<br>0.00E+00<br>1.76E-01<br>5.32E+00* | .4364<br>22912.3<br>2.45E-04<br>1.5616<br>1.7196<br>-9.1323<br>0.00E+00<br>1.76E-01<br>1.23E+02* | .4554<br>21959.7<br>3.07E-06<br>-9.1323<br>1.5880<br>7.14E-02<br>1.11E-01<br>9.77E-02<br>1.79E+03* | .4756<br>21028.0<br>7.29E-02<br>1.7196<br>1.5880<br>7.14E-02<br>1.11E-01<br>9.77E-02<br>1.79E+03*  | .4971<br>20117.6<br>4.30E-01<br>1.6291<br>1.6291<br>1.11E-01<br>2.11E+04<br>1.81E+05<br>1.17E+04   | .5201<br>19228.6<br>7.67E-02<br>1.3618<br>1.3618<br>9.77E-02<br>7.69E+04<br>2.29E+04<br>7.35E+04 | .5446<br>18361.1<br>7.99E-02<br>1.3283<br>1.3283<br>1.96E-01<br>2.00E+04<br>2.05E+04<br>2.05E+04     | .5709<br>17515.2<br>2.11E-02<br>1.4441<br>1.4441<br>2.09E-01<br>1.64E-01<br>2.01E-01<br>2.01E-01     | .5991<br>16691.2<br>2.36E-03<br>1.4441<br>1.4441<br>1.64E-01<br>1.20E+03<br>1.10E+03*                |
| 10                  | .3739<br>26747.4<br>9.18E-11<br>1.6990<br>7.69E-02<br>( 4.21E-05)<br>3.00E-06*  | .3886<br>25732.7<br>9.03E-10<br>1.548<br>6.00E-02<br>1.01E-01<br>2.78E-02*                             | .4042<br>24738.5<br>6.60E-07<br>1.6192<br>6.12E-07<br>9.61E-02<br>1.84E-01*                      | .4208<br>23764.9<br>2.92E-07<br>-1.3590<br>6.12E-07<br>1.66E-01<br>2.24E+01*                     | .4384<br>22812.2<br>5.07E-04<br>1.6343<br>6.28E-02<br>1.41E+02*                                    | .4570<br>21880.6<br>3.92E-04<br>.4800<br>6.28E-02<br>3.63E+03*                                     | .4769<br>20970.2<br>7.75E-02<br>1.7533<br>1.6070<br>1.6070<br>1.67E+05<br>8.82E+03<br>1.75E+05     | .4790<br>20081.2<br>4.63E-01<br>1.6894<br>1.6894<br>1.18E+04<br>6.74E+04<br>1.29E+04<br>6.31E+04 | .5205<br>19213.7<br>6.49E-02<br>6.65E-02<br>7.96E-02<br>7.96E-02<br>6.74E+04<br>2.76E+04<br>6.31E+04 | .5444<br>18367.8<br>6.65E-02<br>3.10E-02<br>7.96E-02<br>7.96E-02<br>6.74E+04<br>2.76E+04<br>6.31E+04 | .5700<br>17543.8<br>3.10E-02<br>3.10E-02<br>2.01E-01<br>2.01E-01<br>2.76E+04<br>2.76E+04<br>6.31E+04 |
| 11                  | .3628<br>27565.0<br>7.76E-12<br>1.2261<br>2.44E-01<br>( 3.92E-05)<br>3.37E-05*  | .3766<br>26550.2<br>6.41E-10<br>1.9175<br>3.13E-02<br>2.89E-01<br>1.27E-01*                            | .3913<br>25556.0<br>1.24E-08<br>.9925<br>1.7465<br>6.45E-02<br>1.84E-01*                         | .4068<br>24582.4<br>1.86E-06<br>1.7465<br>.7787<br>2.68E-01<br>2.24E+01*                         | .4232<br>23629.8<br>8.23E-06<br>.7787<br>1.7134<br>7.30E-02<br>1.72E-01                            | .4406<br>22698.1<br>8.36E-04<br>1.7134<br>1.0710<br>2.81E-01<br>6.82E+03                           | .4590<br>21787.7<br>2.05E-03<br>1.0710<br>1.7947<br>5.33E-02<br>7.85E+03                           | .4785<br>20898.7<br>7.46E-02<br>1.7947<br>1.6269<br>9.84E-02<br>1.56E+05                         | .4992<br>20031.2<br>4.93E-01<br>1.6269<br>1.7496<br>6.37E-02<br>7.26E+03                             | .5212<br>19185.3<br>6.25E-02<br>1.7496<br>1.3189<br>2.12E-01<br>5.74E+04                             | .5446<br>18361.3<br>5.09E-02<br>1.3189<br>2.12E-01<br>5.18E-02<br>5.19E+04                           |
| 12                  | .3528<br>28347.3<br>8.75E-15<br>-3.7600<br>8.94E-25<br>( 0.00E+00)<br>5.09E-06* | .3659<br>27332.5<br>1.41E-10<br>1.4233<br>1.772E-01<br>( 3.45E-04)<br>( 3.64E-07)                      | .3797<br>26338.3<br>1.38E-09<br>2.3996<br>1.88E-03<br>2.27E-01<br>5.03E-01*                      | .3942<br>25364.7<br>1.86E-06<br>1.2767<br>1.9274<br>2.98E-02<br>2.27E-01                         | .4096<br>24412.1<br>8.23E-06<br>1.9274<br>1.1775<br>2.59E-01<br>2.98E-02                           | .4259<br>23480.4<br>3.27E-06<br>1.1775<br>1.8115<br>4.98E-02<br>2.59E-01                           | .4431<br>22570.0<br>1.72E+02<br>1.8115<br>1.2987<br>2.19E-01<br>4.98E-02                           | .4612<br>21681.0<br>2.05E-03<br>1.2987<br>1.8493<br>4.24E-02<br>9.44E+03*                        | .4805<br>20813.5<br>6.04E-03<br>1.8493<br>1.6476<br>9.19E-02<br>1.42E+05                             | .5008<br>19967.6<br>6.38E-02<br>5.21E-01<br>6.37E-02<br>5.21E+05                                     | .5224<br>19143.6<br>6.83E-02<br>1.8019<br>1.8019<br>5.18E-02<br>5.21E+03                             |
| 13                  | .3437<br>29094.1<br>7.80E-14<br>1.9524<br>2.65E-02<br>( 5.46E-09)<br>9.11E-08*  | .3561<br>28079.4<br>4.36E-12<br>1.5946<br>1.09E-01<br>0.00E+00<br>8.71E-05*                            | .3692<br>27085.1<br>1.03E-09<br>9.5421<br>0.00E+00<br>1.76E-01<br>3.33E-04*                      | .3830<br>26111.6<br>9.08E-11<br>1.4485<br>1.62E-01<br>1.76E-01<br>7.05E-02*                      | .3975<br>25158.9<br>8.78E-07<br>1.4485<br>3.62E-03<br>1.72E+02<br>1.00E+00*                        | .4128<br>24227.3<br>3.27E-06<br>1.4485<br>1.94E-01<br>1.27E+02<br>6.92E+00*                        | .4289<br>23316.9<br>1.73E-04<br>1.94E-01<br>2.57E-02<br>1.20E+04<br>2.52E+02*                      | .4459<br>22427.9<br>1.08E-03<br>1.9584<br>2.57E-02<br>1.70E-01<br>5.23E+01*                      | .4638<br>21560.3<br>1.33E-02<br>1.4287<br>1.9303<br>1.25E+04   | .4828<br>20714.5<br>4.61E-02<br>1.9303<br>1.6688<br>4.32E+01   | .5028<br>19890.5<br>5.43E-01<br>1.6688<br>1.6688<br>5.12E+03   |
| 14                  | .3355<br>29805.4<br>2.40E-14<br>1.4872<br>1.48E-01<br>( 5.61E-08)<br>2.49E-08*  | .3473<br>28790.6<br>2.56E-13<br>1.6460<br>3.45E-05<br>2.62E-01<br>5.93E-04                             | .3598<br>27796.4<br>9.92E-11<br>1.8020<br>1.49E-01<br>5.18E-02<br>8.07E-04                       | .3728<br>26822.8<br>3.85E-09<br>.4353<br>1.10E-01<br>1.49E-01<br>2.51E-02                        | .3865<br>25870.2<br>1.62E-08<br>1.4353<br>1.5906<br>1.49E-01<br>2.11E+00                           | .4010<br>24938.6<br>2.75E-06<br>1.5906<br>4.7919<br>1.49E-01<br>2.27E-31                           | .4162<br>24028.1<br>4.71E-07<br>4.7919<br>1.49E-01<br>1.44E-01<br>4.60E+02                         | .4322<br>23139.1<br>4.40E-04<br>1.49E-01<br>2.2675<br>1.44E-01<br>6.35E+02*                      | .4490<br>22271.6<br>6.58E-04<br>1.44E-01<br>2.2675<br>1.5198<br>3.31E+02*                            | .4667<br>21425.8<br>2.42E-02<br>1.35E-01<br>2.05E-11<br>1.42E+03                                     | .4854<br>20601.7<br>2.49E-02<br>1.38E-02<br>1.38E-02<br>1.18E-01<br>1.18E+03                         |
| 15                  | .3281<br>30480.8<br>1.92E-15<br>1.0276<br>2.87E-01<br>( 1.81E-08)<br>2.49E-08*  | .3394<br>29466.1<br>3.53E-13<br>1.7013<br>7.63E-02<br>1.07E-04*  | .3512<br>28471.8<br>2.17E-13<br>-3.2691<br>3.87E-20<br>1.55E-04*                                 | .3637<br>27498.3<br>8.91E-10<br>1.4086<br>1.78E-01<br>1.99E-04*                                  | .3767<br>26545.6<br>6.56E-09<br>2.2017<br>1.1167<br>3.48E-01*                                      | .3904<br>25614.0<br>2.23E-07<br>1.1167<br>1.7443<br>1.02E+00*                                      | .4048<br>24703.6<br>5.90E-06<br>1.7443<br>.1876<br>3.38E+01*                                       | .4199<br>23814.5<br>5.13E-06<br>1.876<br>1.6040<br>3.53E+02*                                     | .4358<br>22947.0<br>8.63E-04<br>1.6040<br>4.0614<br>1.47E+04   | .4525<br>22101.2<br>8.07E-05<br>4.0614<br>1.5933<br>1.88E+03*  | .4700<br>21277.1<br>3.73E-02<br>1.5933<br>1.5933<br>1.49E+04   |

Table 18. Radiative transition parameters for  $O_2^+ b ^4\Sigma_g^- - a ^4\Pi_u$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ),  $\nu_{v'v''}$  ( $\text{cm}^{-1}$ ),  $q_{v'v''}$ ,  $\bar{r}_{v'v''}$  ( $\text{\AA}$ ),  $R_e(\bar{r}_{v'v''})$  (electric dipole moment atomic units),  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by the  $r$ -centroid method, and  $A_{v'v''}$  ( $\text{s}^{-1}$ ) calculated by integrating  $\int \psi_{v'}^* R_e(r) \psi_{v''} dr$ . - Continued

| $V' \setminus V''$ | 11          | 12          | 13          | 14          | 15          | 16          | 17          | 18          | 19          | 20          | 21     |
|--------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------|
| 8                  | .6666       | .7032       | .7427       | .7857       | .8323       | .8830       | .9383       | .9987       | 1.0647      | 1.1370      | 1.2162 |
| 15001.7            | 14221.6     | 13463.8     | 12728.3     | 12015.3     | 11325.1     | 10657.7     | 10013.5     | 9392.7      | 8795.4      | 8222.2      |        |
| 4.37E-02           | 2.24E-02    | 4.86E-03    | 3.88E-05    | 4.41E-03    | 1.16E-02    | 1.75E-02    | 2.06E-02    | 2.12E-02    | 2.00E-02    | 1.78E-02    |        |
| 1.2767             | 1.2461      | 1.2046      | 1.6442      | 1.2463      | 1.2160      | 1.1977      | 1.1833      | 1.1712      | 1.1607      | 1.1515      |        |
| 2.27E-01           | 2.38E-01    | 2.51E-01    | 9.30E-02    | 2.38E-01    | 2.47E-01    | 2.53E-01    | 2.57E-01    | 2.60E-01    | 2.63E-01    | 2.65E-01    |        |
| 3.09E+04           | 1.48E+04    | 3.02E+03    | ( 2.80E+00) | 1.75E+03    | 4.19E+03    | 5.49E+03    | 5.54E+03    | 4.82E+03    | 3.80E+03    | 2.82E+03    |        |
| 3.09E+04           | 1.50E+04    | 3.16E+03*   | 8.01E-01*   | 1.68E+03*   | 4.11E+03    | 5.44E+03    | 5.51E+03    | 4.80E+03    | 3.81E+03    | 2.83E+03    |        |
| 9                  | .6294       | .6619       | .6968       | .7344       | .7750       | .8188       | .8662       | .9174       | .9728       | 1.0328      | 1.0977 |
| 15889.1            | 15109.1     | 14351.2     | 13615.7     | 12902.8     | 12212.5     | 11545.2     | 10901.0     | 10280.1     | 9682.9      | 9109.7      |        |
| 2.86E-02           | 4.10E-02    | 3.00E-02    | 1.27E-02    | 2.08E-03    | 2.05E-04    | 3.71E-03    | 8.71E-03    | 1.28E-02    | 1.52E-02    | 1.59E-02    |        |
| 1.3205             | 1.2837      | 1.2545      | 1.2247      | 1.1718      | 1.3953      | 1.2405      | 1.2120      | 1.1946      | 1.1812      | 1.1701      |        |
| 2.11E-01           | 2.25E-01    | 2.35E-01    | 2.45E-01    | 2.60E-01    | 1.83E-01    | 2.40E-01    | 2.49E-01    | 2.54E-01    | 2.57E-01    | 2.61E-01    |        |
| 2.08E+04           | 2.90E+04    | 1.98E+04    | 7.80E+03    | 1.23E+03    | ( 5.06E+01) | 1.33E+03    | 2.82E+03    | 3.63E+03    | 3.71E+03    | 3.31E+03    |        |
| 2.04E+04           | 2.88E+04    | 2.00E+04    | 7.97E+03    | 1.31E+03*   | 4.22E+01*   | 1.28E+03*   | 2.77E+03*   | 3.59E+03    | 3.68E+03    | 3.30E+03    |        |
| 10                 | .5973       | .6265       | .6577       | .6912       | .7270       | .7654       | .8066       | .8508       | .8983       | .9492       | 1.0038 |
| 16741.7            | 15961.6     | 15203.8     | 14468.3     | 13755.4     | 13065.1     | 12397.8     | 11753.5     | 11132.7     | 10535.4     | 9962.3      |        |
| 4.82E-06           | 1.59E-02    | 3.36E-02    | 3.25E-02    | 1.99E-02    | 7.51E-03    | 1.03E-03    | 2.22E-04    | 2.63E-03    | 5.95E-03    | 8.78E-03    |        |
| -1.2754            | 1.3326      | 1.2905      | 1.2614      | 1.2349      | 1.2044      | 1.1366      | 1.3784      | 1.2407      | 1.2115      | 1.1942      |        |
| 1.54E-06           | 2.07E-01    | 2.22E-01    | 2.33E-01    | 2.41E-01    | 2.51E-01    | 2.69E-01    | 1.90E-01    | 2.39E-01    | 2.49E-01    | 2.54E-01    |        |
| ( 2.19E-10)        | 1.12E+04    | 2.37E+04    | 2.16E+04    | 1.22E+04    | 4.27E+03    | 5.74E+02    | ( 5.26E+01) | 8.44E+02    | 1.74E+03    | 2.27E+03    |        |
| 1.65E+02           | 1.09E+04    | 2.34E+04    | 2.16E+04    | 1.23E+04    | 4.40E+03*   | 6.33E+02*   | 4.57E+01*   | 8.11E+02*   | 1.71E+03*   | 2.24E+03*   |        |
| 11                 | .5695       | .5960       | .6242       | .6542       | .6862       | .7203       | .7567       | .7955       | .8368       | .8808       | .9277  |
| 17559.2            | 16779.2     | 16021.3     | 15285.8     | 14572.9     | 13882.6     | 13215.3     | 12571.1     | 11950.2     | 11353.0     | 10779.8     |        |
| 3.80E-02           | 1.82E-03    | 7.00E-03    | 2.44E-02    | 3.05E-02    | 2.41E-02    | 1.34E-02    | 4.90E-03    | 7.03E-04    | 1.06E-04    | 1.52E-03    |        |
| 1.3625             | 1.1963      | 1.3511      | 1.2977      | 1.2675      | 1.2424      | 1.2176      | 1.1865      | 1.1114      | 1.4459      | 1.2495      |        |
| 1.96E-01           | 2.53E-01    | 2.00E-01    | 2.20E-01    | 2.30E-01    | 2.39E-01    | 2.47E-01    | 2.56E-01    | 2.74E-01    | 1.63E-01    | 2.37E-01    |        |
| 3.19E+04           | 2.23E+03    | 4.66E+03    | 1.71E+04    | 2.03E+04    | 1.49E+04    | 7.63E+03    | 2.58E+03    | ( 3.66E+02) | ( 1.68E+01) | 4.33E+02    |        |
| 3.29E+04           | 2.43E+03*   | 4.43E+03*   | 1.67E+04    | 2.02E+04    | 1.50E+04    | 7.75E+03    | 2.68E+03*   | 4.11E+02*   | 1.44E+01*   | 4.14E+02*   |        |
| 12                 | .5452       | .5694       | .5951       | .6223       | .6512       | .6819       | .7144       | .7489       | .7854       | .8240       | .8649  |
| 18341.5            | 17561.5     | 16803.6     | 16068.1     | 15355.2     | 14664.9     | 13997.6     | 13535.4     | 12732.5     | 12135.3     | 11562.1     |        |
| 3.53E-02           | 4.21E-02    | 5.34E-03    | 2.02E-03    | 1.57E-02    | 2.54E-02    | 2.48E-02    | 1.77E-02    | 9.60E-03    | 3.70E-03    | 7.05E-04    |        |
| 1.2598             | 1.3809      | 1.2508      | 1.3904      | 1.3063      | 1.2736      | 1.2489      | 1.2264      | 1.2031      | 1.1729      | 1.1068      |        |
| 2.33E-01           | 1.89E-01    | 2.36E-01    | 1.85E-01    | 2.17E-01    | 2.28E-01    | 2.37E-01    | 2.44E-01    | 2.51E-01    | 2.60E-01    | 2.75E-01    |        |
| ( 4.80E+04)        | 3.29E+04    | 5.73E+03    | ( 1.16E+03) | 1.08E+04    | 1.70E+04    | 1.55E+04    | 1.02E+04    | 5.07E+03    | 1.81E+03    | ( 3.35E+02) |        |
| 4.16E+04           | 3.44E+04    | 5.89E+03*   | 1.04E+03*   | 1.05E+04    | 1.67E+04    | 1.54E+04    | 1.02E+04    | 5.16E+03*   | 1.88E+03*   | 3.72E+02*   |        |
| 13                 | .5239       | .5462       | .5698       | .5947       | .6210       | .6489       | .6782       | .7092       | .7419       | .7763       | .8124  |
| 19088.4            | 18308.3     | 17550.5     | 16815.0     | 16102.1     | 15411.8     | 14744.5     | 14100.2     | 13479.4     | 12882.1     | 12309.0     |        |
| 8.27E-02           | 2.12E-02    | 4.46E-02    | 8.92E-03    | 1.19E-04    | 8.71E-03    | 1.91E-02    | 2.26E-02    | 1.95E-02    | 1.34E-02    | 7.47E-03    |        |
| 1.8421             | 1.1365      | 1.4053      | 1.2631      | 1.6226      | 1.3179      | 1.2800      | 1.2550      | 1.2336      | 1.2133      | 1.1919      |        |
| 4.38E-02           | 2.69E-01    | 1.79E-01    | 2.32E-01    | 9.98E-02    | 2.12E-01    | 2.26E-01    | 2.35E-01    | 2.42E-01    | 2.48E-01    | 2.54E-01    |        |
| ( 4.47E+03)        | ( 3.81E+04) | 3.13E+04    | 9.25E+03    | ( 2.01E+01) | 5.83E+03    | 1.27E+04    | 1.41E+04    | 1.13E+04    | 7.13E+03    | 3.65E+03    |        |
| 4.00E+03           | 3.28E+04    | 3.38E+04    | 9.27E+03*   | 6.25E+00*   | 5.61E+03*   | 1.24E+04    | 1.40E+04    | 1.13E+04    | 7.20E+03    | 3.73E+03*   |        |
| 14                 | .5051       | .5258       | .5476       | .5706       | .5948       | .6202       | .6470       | .6752       | .7047       | .7357       | .7680  |
| 19799.6            | 19019.6     | 18261.7     | 17526.3     | 16813.3     | 16123.0     | 15455.7     | 14811.5     | 14190.6     | 13593.4     | 13020.2     |        |
| 5.52E-01           | 1.07E-01    | 9.58E-03    | 4.65E-02    | 1.16E-02    | 3.22E-04    | 3.92E-03    | 1.28E-02    | 1.85E-02    | 1.87E-02    | 1.53E-02    |        |
| 1.6903             | 1.8713      | .8343       | 1.4393      | 1.2582      | 1.1518      | 1.3374      | 1.2874      | 1.2611      | 1.2401      | 1.2214      |        |
| 7.94E-02           | 3.85E-02    | 2.79E-01    | 1.66E-01    | 2.34E-01    | 2.65E-01    | 2.05E-01    | 2.23E-01    | 2.33E-01    | 2.40E-01    | 2.46E-01    |        |
| ( 1.09E+05)        | ( 4.42E+03) | ( 1.84E+04) | ( 2.79E+04) | 1.22E+04    | ( 3.84E+02) | 2.47E+03    | 8.43E+03    | 1.16E+04    | 1.09E+04    | 8.24E+03    |        |
| 1.27E+05           | 3.71E+03    | 2.55E+04*   | 3.18E+04    | 1.19E+04    | 5.01E+02*   | 2.32E+03*   | 8.21E+03    | 1.14E+04    | 1.09E+04    | 8.26E+03    |        |
| 15                 | .4884       | .5077       | .5281       | .5494       | .5718       | .5953       | .6199       | .6457       | .6727       | .7008       | .7302  |
| 20475.0            | 19695.0     | 18937.2     | 18201.7     | 17488.7     | 16798.5     | 16131.1     | 15486.9     | 14866.0     | 14268.8     | 13695.6     |        |
| 6.60E-03           | 5.41E-01    | 1.41E-01    | 1.91E-03    | 4.92E-02    | 1.29E-02    | 1.75E-03    | 1.18E-03    | 7.56E-03    | 1.36E-02    | 1.61E-02    |        |
| 2.5309             | 1.7117      | 1.8928      | -3950       | 1.4865      | 1.2360      | 1.2673      | 1.3839      | 1.2968      | 1.2678      | 1.2465      |        |
| 7.21E-04           | 7.35E-02    | 3.50E-02    | 3.35E-03    | 1.48E-01    | 2.41E-01    | 2.31E-01    | 1.87E-01    | 2.20E-01    | 2.30E-01    | 2.38E-01    |        |
| ( 1.19E-01)        | ( 9.03E+04) | ( 4.74E+03) | ( 5.22E-01) | ( 2.33E+04) | 1.44E+04    | ( 1.58E+03) | ( 6.22E+02) | 4.88E+03    | 8.50E+03    | 9.43E+03    |        |
| 6.14E+03*          | 1.09E+05    | 3.93E+03    | 1.97E+04*   | 2.91E+04    | 1.37E+04    | 1.80E+03*   | 5.61E+02*   | 4.69E+03*   | 8.33E+03    | 9.33E+03    |        |

Table 19. Calculated radiative lifetimes (s) of N<sub>2</sub>, N<sub>2</sub><sup>+</sup>, and O<sub>2</sub><sup>+</sup> states as a function of vibrational level.

| <i>v</i> | N <sub>2</sub> A <sup>3</sup> Σ <sub>u</sub> <sup>+</sup> | N <sub>2</sub> B <sup>3</sup> Π <sub>g</sub> | N <sub>2</sub> W <sup>3</sup> Δ <sub>u</sub> | N <sub>2</sub> B' <sup>3</sup> Σ <sub>u</sub> <sup>-</sup> | N <sub>2</sub> a <sup>1</sup> Π <sub>g</sub> | N <sub>2</sub> w <sup>1</sup> Δ <sub>u</sub> | N <sub>2</sub> C <sup>3</sup> Π <sub>u</sub> |
|----------|---|--|--|--|--|--|--|
| 0        | 2.05  | 1.13(-5)*                                    | >1†  | 4.54(-5)   | 5.77(-5)                                     | 7.67(-4)                                     | 3.71(-8)                                     |
| 1        | 2.09  | 9.26(-6)                                     | 4.53(-3)                                     | 3.57(-5)   | 5.68(-5)                                     | 4.08(-4)                                     | 3.75(-8)                                     |
| 2        | 2.12  | 7.87(-6)                                     | 1.22(-3)                                     | 2.98(-5)   | 5.58(-5)                                     | 2.79(-4)                                     | 3.81(-8)                                     |
| 3        | 2.14  | 6.90(-6)                                     | 6.04(-4)                                     | 2.58(-5)   | 5.50(-5)                                     | 2.13(-4)                                     | 3.90(-8)                                     |
| 4        | 2.14  | 6.17(-6)                                     | 3.78(-4)                                     | 2.29(-5)   | 5.42(-5)                                     | 1.72(-4)                                     | 4.04(-8)                                     |
| 5        | 2.14  | 5.62(-6)                                     | 2.66(-4)                                     | 2.07(-5)   | 5.36(-5)                                     | 1.45(-4)                                     |  |
| 6        | 2.16  | 5.19(-6)                                     | 2.02(-4)                                     | 1.90(-5)   | 5.32(-5)                                     | 1.26(-4)                                     |  |
| 7        | 2.36  | 4.85(-6)                                     | 1.61(-4)                                     | 1.76(-5)   | 5.29(-5)§                                    | 1.11(-4)                                     |  |
| 8        | 1.99  | 4.58(-6)                                     | 1.34(-4)                                     | 1.65(-5)   | 5.28(-5)§                                    | 1.00(-4)                                     |  |
| 9        | 1.07  | 4.36(-6)                                     | 1.14(-4)                                     | 1.56(-5)   | 5.29(-5)§                                    | 9.09(-5)                                     |  |
| 10       | 4.61(-1)  | 4.18(-6)                                     | 9.89(-5)                                     | 1.49(-5)   | 5.35(-5)§                                    | 8.35(-5)                                     |  |
| 11       | 2.16(-1)  | 4.04(-6)                                     | 8.76(-5)                                     | 1.42(-5)   | 5.58(-5)§                                    | 7.74(-5)                                     |  |
| 12       | 1.19(-1)  | 3.93(-6)                                     | 7.87(-5)                                     | 1.36(-5)   | 5.98(-5)§                                    | 7.22(-5)                                     |  |
| 13       | 6.92(-2)  | 3.85(-6)†                                    | 7.16(-5)                                     | 1.32(-5)   | 6.10(-5)§                                    | 6.77(-5)                                     |  |
| 14       | 4.36(-2)  | 3.78(-6)†                                    | 6.58(-5)                                     | 1.28(-5)   | 6.30(-5)§                                    | 6.39(-5)                                     |  |
| 15       | 2.98(-2)  | 3.74(-6)†                                    | 6.11(-5)                                     | 1.24(-5)   | 6.49(-5)§                                    | 6.05(-5)                                     |  |
| 16       | 2.11(-2)  | 3.72(-6)†                                    | 5.72(-5)                                     | 1.21(-5)   | 6.73(-5)§                                    | 5.75(-5)                                     |  |
| 17       | 1.58(-2)  | 3.72(-6)†                                    | 5.39(-5)                                     | 1.18(-5)   | 6.88(-5)§                                    | 5.49(-5)                                     |  |
| 18       | 1.24(-2)  | 3.73(-6)†                                    | 5.12(-5)§                                    | 1.16(-5)§  | 7.20(-5)§                                    | 5.25(-5)                                     |  |
| 19       | 1.00(-2)  | 3.76(-6)†                                    | 4.89(-5)§                                    | 1.14(-5)§  | 7.37(-5)§                                    | 5.03(-5)§                                    |  |
| 20       | 8.44(-3)  | 3.80(-6)†                                    | 4.71(-5)§                                    | 1.13(-5)§  | 7.62(-5)§                                    | 4.83(-5)§                                    |  |
| 21       | 7.32(-3)  | 3.84(-6)†                                    | 4.56(-5)§                                    | 1.11(-5)§  | 7.99(-5)§                                    | 4.65(-5)§                                    |  |

\*Read as  $1.13 \times 10^{-5}$ .†Value depends considerably on the spin component and rotational level, and also on the unknown (but slow)  
rate of radiative decay to the ground state.

‡Actual lifetime shorter due to predissociation.

§Value may be significantly too large due to omission of transitions to high vibrational levels of lower electronic states.

Table 19. Calculated radiative lifetimes (s) of  $N_2$ ,  $N_2^+$ , and  $O_2^+$  states as a function of vibrational level. - Continued

| <i>v</i> | $N_2 E \ ^3\Sigma_g^+$ | $N_2 D \ ^3\Sigma_u^+$ | $N_2^+ A \ ^2\Pi_u$ | $N_2^+ B \ ^2\Sigma_u^+$ | $N_2^+ C \ ^2\Sigma_u^+$ | $O_2^+ A \ ^2\Pi_u$ | $O_2^+ b \ ^4\Sigma_g^-$ |
|----------|------------------------|------------------------|---------------------|--------------------------|--------------------------|---------------------|--------------------------|
| 0        | 1.90(-4)*              | 1.41(-8)               | 1.60(-5)            | 6.23(-8)                 | 6.81(-8)                 | 5.97(-7)            | 1.46(-6)                 |
| 1        | 7.49(-5)               |                        | 1.33(-5)            | 6.20(-8)                 | 6.62(-8)                 | 6.09(-7)            | 1.49(-6)                 |
| 2        |                        |                        | 1.15(-5)            | 6.19(-8)                 | 6.42(-8)                 | 6.23(-7)            | 1.54(-6)                 |
| 3        |                        |                        | 1.03(-5)            | 6.23(-8)                 | 6.23(-8)†                | 6.37(-7)            | 1.60(-6)                 |
| 4        |                        |                        | 9.32(-6)            | 6.30(-8)                 | 6.06(-8)†                | 6.53(-7)            | 1.69(-6)†                |
| 5        |                        |                        | 8.61(-6)            | 6.44(-8)                 | 5.91(-8)†                | 6.71(-7)            | 1.79(-6)†                |
| 6        |                        |                        | 8.05(-6)            | 6.64(-8)                 | 5.79(-8)†                | 6.90(-7)            | 1.91(-6)†                |
| 7        |                        |                        | 7.59(-6)            | 6.94(-8)                 | 5.70(-8)†                | 7.11(-7)            | 2.07(-6)†                |
| 8        |                        |                        | 7.22(-6)            | 7.36(-8)                 | 5.65(-8)†                | 7.34(-7)            | 2.25(-6)†                |
| 9        |                        |                        | 6.91(-6)            | 7.95(-8)                 | 5.64(-8)†                | 7.58(-7)            | 2.47(-6)†                |
| 10       |                        |                        | 6.66(-6)            | 8.75(-8)                 | 5.69(-8)†                | 7.85(-7)            | 2.70(-6)†                |
| 11       |                        |                        | 6.44(-6)            |                          |                          | 8.18(-7)            | 2.94(-6)†                |
| 12       |                        |                        | 6.25(-6)            |                          |                          | 8.67(-7)†           | 3.18(-6)†                |
| 13       |                        |                        | 6.10(-6)            |                          |                          | 9.15(-7)†           | 3.46(-6)†                |
| 14       |                        |                        | 5.96(-6)            |                          |                          | 9.54(-7)†           | 3.88(-6)†                |
| 15       |                        |                        | 5.85(-6)            |                          |                          | 1.01(-6)†           | 4.48(-6)†                |
| 16       |                        |                        | 5.75(-6)            |                          |                          | 1.06(-6)†           |                          |
| 17       |                        |                        | 5.67(-6)            |                          |                          | 1.11(-6)†           |                          |
| 18       |                        |                        | 5.61(-6)†           |                          |                          | 1.18(-6)†           |                          |
| 19       |                        |                        | 5.56(-6)†           |                          |                          | 1.25(-6)†           |                          |
| 20       |                        |                        | 5.53(-6)†           |                          |                          | 1.33(-6)†           |                          |
| 21       |                        |                        | 5.50(-6)†           |                          |                          | 1.42(-6)†           |                          |

\*Read as  $1.90 \times 10^{-4}$ .

†Value may be significantly too large due to omission of transitions to high vibrational levels of lower electronic states.

‡Actual lifetime shorter due to predissociation.

Table 20. Franck-Condon factors for N<sub>2</sub> B <sup>3</sup>Π<sub>g</sub>-X <sup>1</sup>Σ<sub>g</sub><sup>+</sup>.

| <i>v'</i> \ <i>v''</i> | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|------------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                      | 6.11(-2)* | 1.91(-1) | 2.74(-1) | 2.41(-1) | 1.44(-1) | 6.24(-2) | 2.03(-2) | 5.02(-3) | 9.65(-4) | 1.44(-4) | 1.68(-5) |
| 1                      | 1.47(-1)  | 1.93(-1) | 4.50(-2) | 1.59(-2) | 1.42(-1) | 2.05(-1) | 1.51(-1) | 7.14(-2) | 2.37(-2) | 5.76(-3) | 1.05(-3) |
| 2                      | 1.95(-1)  | 6.54(-2) | 2.39(-2) | 1.30(-1) | 4.81(-2) | 9.67(-3) | 1.24(-1) | 1.86(-1) | 1.34(-1) | 6.02(-2) | 1.86(-2) |
| 3                      | 1.90(-1)  | 7.17(-4) | 1.05(-1) | 3.60(-2) | 3.09(-2) | 1.11(-1) | 2.50(-2) | 2.43(-2) | 1.41(-1) | 1.72(-1) | 1.08(-1) |
| 4                      | 1.51(-1)  | 2.58(-2) | 8.38(-2) | 7.32(-3) | 9.25(-2) | 6.91(-3) | 5.99(-2) | 8.84(-2) | 3.07(-3) | 5.97(-2) | 1.62(-1) |
| 5                      | 1.05(-1)  | 7.60(-2) | 2.07(-2) | 6.56(-2) | 2.61(-2) | 4.12(-2) | 6.26(-2) | 3.07(-3) | 8.95(-2) | 4.75(-2) | 5.91(-3) |
| 6                      | 6.65(-2)  | 1.04(-1) | 5.33(-4) | 7.50(-2) | 3.74(-3) | 7.11(-2) | 4.31(-5) | 7.35(-2) | 1.72(-2) | 3.77(-2) | 8.79(-2) |
| 7                      | 3.90(-2)  | 1.03(-1) | 2.49(-2) | 3.34(-2) | 4.62(-2) | 1.87(-2) | 4.58(-2) | 2.77(-2) | 2.91(-2) | 5.98(-2) | 1.36(-3) |
| 8                      | 2.16(-2)  | 8.39(-2) | 5.85(-2) | 2.39(-3) | 6.37(-2) | 2.54(-3) | 5.61(-2) | 4.27(-3) | 6.02(-2) | 1.75(-4) | 6.72(-2) |
| 9                      | 1.15(-2)  | 6.04(-2) | 7.72(-2) | 6.14(-3) | 3.82(-2) | 3.48(-2) | 1.36(-2) | 4.60(-2) | 9.13(-3) | 4.67(-2) | 1.79(-2) |
| 10                     | 5.92(-3)  | 3.98(-2) | 7.73(-2) | 3.00(-2) | 8.13(-3) | 5.38(-2) | 1.89(-3) | 4.50(-2) | 1.03(-2) | 4.06(-2) | 1.15(-2) |
| 11                     | 2.98(-3)  | 2.46(-2) | 6.55(-2) | 5.24(-2) | 4.98(-4) | 3.91(-2) | 2.70(-2) | 1.05(-2) | 4.35(-2) | 1.75(-3) | 4.88(-2) |
| 12                     | 1.48(-3)  | 1.45(-2) | 4.96(-2) | 6.29(-2) | 1.35(-2) | 1.35(-2) | 4.55(-2) | 1.33(-3) | 3.70(-2) | 1.48(-2) | 2.47(-2) |
| 13                     | 7.25(-4)  | 8.27(-3) | 3.47(-2) | 6.13(-2) | 3.29(-2) | 3.86(-4) | 3.82(-2) | 2.09(-2) | 8.78(-3) | 3.97(-2) | 1.91(-5) |
| 14                     | 3.54(-4)  | 4.59(-3) | 2.29(-2) | 5.22(-2) | 4.72(-2) | 4.70(-3) | 1.78(-2) | 3.82(-2) | 7.58(-4) | 3.14(-2) | 1.70(-2) |
| 15                     | 1.72(-4)  | 2.51(-3) | 1.45(-2) | 4.06(-2) | 5.23(-2) | 1.86(-2) | 2.80(-3) | 3.63(-2) | 1.57(-2) | 8.10(-3) | 3.56(-2) |
| 16                     | 8.39(-5)  | 1.35(-3) | 8.87(-3) | 2.95(-2) | 4.97(-2) | 3.27(-2) | 7.20(-4) | 2.13(-2) | 3.15(-2) | 2.54(-4) | 2.76(-2) |
| 17                     | 4.12(-5)  | 7.26(-4) | 5.31(-3) | 2.05(-2) | 4.25(-2) | 4.14(-2) | 8.77(-3) | 6.44(-3) | 3.37(-2) | 1.10(-2) | 8.26(-3) |
| 18                     | 2.04(-5)  | 3.88(-4) | 3.14(-3) | 1.37(-2) | 3.38(-2) | 4.37(-2) | 2.03(-2) | 1.08(-4) | 2.37(-2) | 2.51(-2) | 1.87(-6) |
| 19                     | 1.02(-5)  | 2.09(-4) | 1.83(-3) | 8.91(-3) | 2.54(-2) | 4.09(-2) | 3.00(-2) | 2.77(-3) | 1.06(-2) | 3.02(-2) | 6.80(-3) |
| 20                     | 5.17(-6)  | 1.12(-4) | 1.07(-3) | 5.70(-3) | 1.84(-2) | 3.53(-2) | 3.54(-2) | 1.06(-2) | 1.92(-3) | 2.49(-2) | 1.87(-2) |
| 21                     | 2.67(-6)  | 6.11(-5) | 6.20(-4) | 3.60(-3) | 1.29(-2) | 2.87(-2) | 3.64(-2) | 1.93(-2) | 1.75(-4) | 1.46(-2) | 2.57(-2) |

\*Read as  $6.11 \times 10^{-2}$ .

Table 21. Franck-Condon factors for  $N_2 W^3\Delta_u - X^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 1.46(-3)* | 1.15(-2) | 4.26(-2) | 9.90(-2) | 1.62(-1) | 1.98(-1) | 1.88(-1) | 1.42(-1) | 8.66(-2) | 4.32(-2) | 1.77(-2) |
| 1                  | 7.46(-3)  | 4.25(-2) | 1.04(-1) | 1.38(-1) | 9.47(-2) | 2.00(-2) | 5.18(-3) | 6.77(-2) | 1.38(-1) | 1.54(-1) | 1.18(-1) |
| 2                  | 2.04(-2)  | 8.14(-2) | 1.20(-1) | 6.49(-2) | 1.39(-3) | 3.66(-2) | 9.31(-2) | 6.18(-2) | 3.82(-3) | 2.50(-2) | 1.02(-1) |
| 3                  | 3.97(-2)  | 1.06(-1) | 7.80(-2) | 3.31(-3) | 3.56(-2) | 7.72(-2) | 2.25(-2) | 8.07(-3) | 7.07(-2) | 7.01(-2) | 9.81(-3) |
| 4                  | 6.18(-2)  | 1.03(-1) | 2.41(-2) | 1.51(-2) | 6.90(-2) | 2.05(-2) | 1.21(-2) | 6.61(-2) | 2.93(-2) | 4.04(-3) | 6.36(-2) |
| 5                  | 8.18(-2)  | 7.73(-2) | 2.40(-4) | 5.17(-2) | 3.75(-2) | 3.44(-3) | 5.62(-2) | 2.26(-2) | 9.58(-3) | 6.10(-2) | 2.41(-2) |
| 6                  | 9.60(-2)  | 4.32(-2) | 1.13(-2) | 5.85(-2) | 2.62(-3) | 3.83(-2) | 3.32(-2) | 3.80(-3) | 5.22(-2) | 1.53(-2) | 1.55(-2) |
| 7                  | 1.02(-1)  | 1.53(-2) | 3.60(-2) | 3.41(-2) | 8.17(-3) | 4.76(-2) | 7.60(-4) | 3.93(-2) | 2.23(-2) | 9.91(-3) | 4.96(-2) |
| 8                  | 1.01(-1)  | 1.44(-3) | 5.23(-2) | 7.76(-3) | 3.33(-2) | 2.10(-2) | 1.44(-2) | 3.74(-2) | 6.99(-4) | 4.31(-2) | 8.68(-3) |
| 9                  | 9.43(-2)  | 1.69(-3) | 5.15(-2) | 2.67(-4) | 4.36(-2) | 7.12(-4) | 3.77(-2) | 7.15(-3) | 2.63(-2) | 2.22(-2) | 9.33(-3) |
| 10                 | 8.34(-2)  | 1.16(-2) | 3.76(-2) | 1.11(-2) | 3.14(-2) | 7.39(-3) | 3.28(-2) | 2.62(-3) | 3.63(-2) | 4.57(-6) | 3.64(-2) |
| 11                 | 7.07(-2)  | 2.55(-2) | 1.99(-2) | 2.74(-2) | 1.17(-2) | 2.58(-2) | 1.11(-2) | 2.23(-2) | 1.48(-2) | 1.64(-2) | 2.23(-2) |
| 12                 | 5.79(-2)  | 3.85(-2) | 6.14(-3) | 3.75(-2) | 5.84(-4) | 3.44(-2) | 2.57(-5) | 3.26(-2) | 5.32(-5) | 3.19(-2) | 7.34(-4) |
| 13                 | 4.61(-2)  | 4.79(-2) | 2.14(-4) | 3.70(-2) | 3.05(-3) | 2.72(-2) | 7.38(-3) | 2.20(-2) | 9.42(-3) | 2.06(-2) | 9.04(-3) |
| 14                 | 3.58(-2)  | 5.27(-2) | 1.95(-3) | 2.82(-2) | 1.38(-2) | 1.28(-2) | 2.13(-2) | 5.69(-3) | 2.45(-2) | 3.00(-3) | 2.58(-2) |
| 15                 | 2.72(-2)  | 5.33(-2) | 8.92(-3) | 1.63(-2) | 2.47(-2) | 2.08(-3) | 2.80(-2) | 9.71(-5) | 2.61(-2) | 1.95(-3) | 2.36(-2) |
| 16                 | 2.03(-2)  | 5.05(-2) | 1.81(-2) | 6.24(-3) | 2.98(-2) | 5.18(-4) | 2.36(-2) | 7.11(-3) | 1.47(-2) | 1.41(-2) | 8.31(-3) |
| 17                 | 1.50(-2)  | 4.56(-2) | 2.69(-2) | 7.81(-4) | 2.79(-2) | 6.63(-3) | 1.29(-2) | 1.78(-2) | 2.96(-3) | 2.31(-2) | 2.62(-5) |
| 18                 | 1.09(-2)  | 3.96(-2) | 3.36(-2) | 4.37(-4) | 2.11(-2) | 1.54(-2) | 3.48(-3) | 2.33(-2) | 3.27(-4) | 2.03(-2) | 5.47(-3) |
| 19                 | 7.83(-3)  | 3.33(-2) | 3.77(-2) | 4.16(-3) | 1.25(-2) | 2.21(-2) | 6.80(-7) | 2.06(-2) | 6.41(-3) | 1.01(-2) | 1.58(-2) |
| 20                 | 5.57(-3)  | 2.73(-2) | 3.91(-2) | 1.02(-2) | 5.19(-3) | 2.41(-2) | 2.74(-3) | 1.27(-2) | 1.48(-2) | 1.70(-3) | 2.02(-2) |
| 21                 | 3.92(-3)  | 2.18(-2) | 3.81(-2) | 1.69(-2) | 9.17(-4) | 2.16(-2) | 6.98(-3) | 4.73(-3) | 1.94(-2) | 4.20(-4) | 1.59(-2) |

\*Read as  $1.46 \times 10^{-3}$ .

Table 22. Franck-Condon factors for N<sub>2</sub> B' 3Σ<sub>u</sub><sup>-</sup>-X 1Σ<sub>g</sub><sup>+</sup>.

| <i>v'</i> \ <i>v''</i> | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|------------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                      | 1.58(-3)* | 1.23(-2) | 4.50(-2) | 1.03(-1) | 1.66(-1) | 2.00(-1) | 1.87(-1) | 1.38(-1) | 8.26(-2) | 4.02(-2) | 1.61(-2) |
| 1                      | 8.02(-3)  | 4.49(-2) | 1.08(-1) | 1.38(-1) | 9.07(-2) | 1.64(-2) | 7.75(-3) | 7.49(-2) | 1.43(-1) | 1.54(-1) | 1.13(-1) |
| 2                      | 2.18(-2)  | 8.48(-2) | 1.20(-1) | 6.08(-2) | 4.97(-4) | 4.19(-2) | 9.49(-2) | 5.66(-2) | 1.76(-3) | 3.18(-2) | 1.11(-1) |
| 3                      | 4.20(-2)  | 1.08(-1) | 7.49(-2) | 1.86(-3) | 4.05(-2) | 7.66(-2) | 1.80(-2) | 1.20(-2) | 7.56(-2) | 6.52(-2) | 5.76(-3) |
| 4                      | 6.49(-2)  | 1.03(-1) | 2.07(-2) | 1.88(-2) | 6.97(-2) | 1.62(-2) | 1.66(-2) | 6.76(-2) | 2.36(-2) | 7.74(-3) | 6.95(-2) |
| 5                      | 8.52(-2)  | 7.50(-2) | 8.05(-7) | 5.53(-2) | 3.33(-2) | 6.06(-3) | 5.83(-2) | 1.75(-2) | 1.45(-2) | 6.25(-2) | 1.78(-2) |
| 6                      | 9.91(-2)  | 3.98(-2) | 1.45(-2) | 5.78(-2) | 1.08(-3) | 4.28(-2) | 2.85(-2) | 7.13(-3) | 5.36(-2) | 1.02(-2) | 2.22(-2) |
| 7                      | 1.05(-1)  | 1.26(-2) | 4.01(-2) | 3.04(-2) | 1.17(-2) | 4.62(-2) | 2.48(-5) | 4.33(-2) | 1.69(-2) | 1.54(-2) | 4.81(-2) |
| 8                      | 1.02(-1)  | 5.92(-4) | 5.45(-2) | 5.12(-3) | 3.74(-2) | 1.66(-2) | 1.93(-2) | 3.38(-2) | 2.81(-3) | 4.46(-2) | 4.28(-3) |
| 9                      | 9.44(-2)  | 3.05(-3) | 5.09(-2) | 1.22(-3) | 4.38(-2) | 2.17(-5) | 4.01(-2) | 3.74(-3) | 3.16(-2) | 1.66(-2) | 1.52(-2) |
| 10                     | 8.25(-2)  | 1.47(-2) | 3.48(-2) | 1.48(-2) | 2.80(-2) | 1.13(-2) | 2.96(-2) | 5.82(-3) | 3.45(-2) | 7.66(-4) | 3.81(-2) |
| 11                     | 6.92(-2)  | 2.93(-2) | 1.66(-2) | 3.14(-2) | 8.19(-3) | 3.00(-2) | 7.17(-3) | 2.71(-2) | 9.87(-3) | 2.23(-2) | 1.66(-2) |
| 12                     | 5.60(-2)  | 4.22(-2) | 3.98(-3) | 3.96(-2) | 8.97(-6) | 3.49(-2) | 4.06(-4) | 3.25(-2) | 4.66(-4) | 3.24(-2) | 3.01(-5) |
| 13                     | 4.40(-2)  | 5.08(-2) | 4.29(-6) | 3.63(-2) | 5.77(-3) | 2.42(-2) | 1.17(-2) | 1.77(-2) | 1.46(-2) | 1.56(-2) | 1.48(-2) |
| 14                     | 3.38(-2)  | 5.45(-2) | 3.69(-3) | 2.55(-2) | 1.81(-2) | 9.02(-3) | 2.54(-2) | 2.54(-3) | 2.78(-2) | 6.00(-4) | 2.85(-2) |
| 15                     | 2.54(-2)  | 5.39(-2) | 1.20(-2) | 1.31(-2) | 2.82(-2) | 5.20(-4) | 2.88(-2) | 1.41(-3) | 2.41(-2) | 5.53(-3) | 1.97(-2) |
| 16                     | 1.87(-2)  | 5.01(-2) | 2.17(-2) | 3.92(-3) | 3.11(-2) | 2.14(-3) | 2.09(-2) | 1.16(-2) | 1.01(-2) | 1.93(-2) | 3.87(-3) |
| 17                     | 1.36(-2)  | 4.44(-2) | 3.02(-2) | 1.01(-4) | 2.68(-2) | 1.04(-2) | 9.10(-3) | 2.19(-2) | 6.71(-4) | 2.44(-2) | 8.44(-4) |
| 18                     | 9.78(-3)  | 3.79(-2) | 3.62(-2) | 1.50(-3) | 1.84(-2) | 1.95(-2) | 1.25(-3) | 2.42(-2) | 2.28(-3) | 1.70(-2) | 1.05(-2) |
| 19                     | 6.95(-3)  | 3.13(-2) | 3.93(-2) | 6.58(-3) | 9.56(-3) | 2.47(-2) | 5.97(-4) | 1.83(-2) | 1.10(-2) | 5.79(-3) | 2.00(-2) |
| 20                     | 4.89(-3)  | 2.53(-2) | 3.95(-2) | 1.33(-2) | 3.04(-3) | 2.47(-2) | 5.75(-3) | 9.07(-3) | 1.88(-2) | 1.05(-4) | 2.00(-2) |
| 21                     | 3.42(-3)  | 2.00(-2) | 3.77(-2) | 2.00(-2) | 1.44(-4) | 2.02(-2) | 1.30(-2) | 2.05(-3) | 2.06(-2) | 2.67(-3) | 1.21(-2) |

\*Read as 1.58 × 10<sup>-3</sup>.

Table 23. Franck-Condon factors for  $\text{N}_2 \ a' \ ^1\Sigma_u^- - X \ ^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 1.89(-3)* | 1.42(-2) | 5.06(-2) | 1.12(-1) | 1.75(-1) | 2.04(-1) | 1.83(-1) | 1.31(-1) | 7.48(-2) | 3.49(-2) | 1.33(-2) |
| 1                  | 9.35(-3)  | 5.03(-2) | 1.15(-1) | 1.39(-1) | 8.17(-2) | 9.91(-3) | 1.44(-2) | 3.91(-2) | 1.51(-1) | 1.51(-1) | 1.04(-1) |
| 2                  | 2.48(-2)  | 9.16(-2) | 1.20(-1) | 5.18(-2) | 7.48(-5) | 5.27(-2) | 9.62(-2) | 4.59(-2) | 1.26(-5) | 4.57(-2) | 1.24(-1) |
| 3                  | 4.69(-2)  | 1.12(-1) | 6.75(-2) | 1.88(-4) | 5.00(-2) | 7.33(-2) | 1.02(-2) | 2.12(-2) | 8.24(-2) | 5.48(-2) | 1.11(-3) |
| 4                  | 7.10(-2)  | 1.02(-1) | 1.43(-2) | 2.66(-2) | 6.90(-2) | 9.18(-3) | 2.60(-2) | 5.78(-2) | 1.41(-2) | 1.68(-2) | 7.71(-2) |
| 5                  | 9.14(-2)  | 6.93(-2) | 7.37(-4) | 6.09(-2) | 2.52(-2) | 1.25(-2) | 5.87(-2) | 9.44(-3) | 2.46(-2) | 6.16(-2) | 8.48(-3) |
| 6                  | 1.04(-1)  | 3.30(-2) | 2.11(-2) | 5.47(-2) | 1.29(-6) | 4.93(-2) | 1.98(-2) | 1.49(-2) | 5.29(-2) | 3.42(-3) | 3.41(-2) |
| 7                  | 1.08(-1)  | 7.99(-3) | 4.69(-2) | 2.32(-2) | 1.90(-2) | 4.17(-2) | 1.17(-3) | 4.78(-2) | 8.70(-3) | 2.58(-2) | 4.23(-2) |
| 8                  | 1.04(-1)  | 5.02(-7) | 5.70(-2) | 1.68(-3) | 4.32(-2) | 9.68(-3) | 2.79(-2) | 2.61(-2) | 8.94(-3) | 4.34(-2) | 3.35(-4) |
| 9                  | 9.36(-2)  | 6.40(-3) | 4.81(-2) | 4.40(-3) | 4.20(-2) | 1.05(-3) | 4.15(-2) | 4.23(-4) | 3.81(-2) | 8.27(-3) | 2.54(-2) |
| 10                 | 8.03(-2)  | 2.06(-2) | 2.91(-2) | 2.18(-2) | 2.14(-2) | 1.86(-2) | 2.27(-2) | 1.28(-2) | 2.89(-2) | 5.28(-3) | 3.68(-2) |
| 11                 | 6.60(-2)  | 3.60(-2) | 1.12(-2) | 3.72(-2) | 3.48(-3) | 3.51(-2) | 2.33(-3) | 3.30(-2) | 3.63(-3) | 3.01(-2) | 8.19(-3) |
| 12                 | 5.24(-2)  | 4.82(-2) | 1.28(-3) | 4.10(-2) | 9.99(-4) | 3.33(-2) | 3.47(-3) | 2.95(-2) | 4.16(-3) | 2.94(-2) | 2.86(-3) |
| 13                 | 4.04(-2)  | 5.51(-2) | 9.26(-4) | 3.34(-2) | 1.14(-2) | 1.81(-2) | 1.90(-2) | 1.06(-2) | 2.24(-2) | 7.98(-3) | 2.33(-2) |
| 14                 | 3.03(-2)  | 5.68(-2) | 7.70(-3) | 2.02(-2) | 2.47(-2) | 3.94(-3) | 2.98(-2) | 9.51(-5) | 2.94(-2) | 4.59(-4) | 2.83(-2) |
| 15                 | 2.23(-2)  | 5.42(-2) | 1.78(-2) | 8.10(-3) | 3.21(-2) | 1.89(-4) | 2.70(-2) | 5.94(-3) | 1.85(-2) | 1.27(-2) | 1.22(-2) |
| 16                 | 1.61(-2)  | 4.88(-2) | 2.79(-2) | 1.16(-3) | 3.10(-2) | 6.53(-3) | 1.51(-2) | 1.86(-2) | 4.12(-3) | 2.48(-2) | 2.60(-4) |
| 17                 | 1.15(-2)  | 4.20(-2) | 3.56(-2) | 3.94(-4) | 2.33(-2) | 1.68(-2) | 3.95(-3) | 2.57(-2) | 3.01(-4) | 2.26(-2) | 5.57(-3) |
| 18                 | 8.10(-3)  | 3.49(-2) | 4.00(-2) | 4.57(-3) | 1.34(-2) | 2.47(-2) | 5.40(-6) | 2.25(-2) | 7.62(-3) | 1.06(-2) | 1.78(-2) |
| 19                 | 5.64(-3)  | 2.81(-2) | 4.13(-2) | 1.15(-2) | 5.15(-3) | 2.68(-2) | 3.77(-3) | 1.30(-2) | 1.76(-2) | 1.23(-3) | 2.24(-2) |
| 20                 | 3.90(-3)  | 2.21(-2) | 3.99(-2) | 1.89(-2) | 6.61(-4) | 2.32(-2) | 1.15(-2) | 3.95(-3) | 2.22(-2) | 1.20(-3) | 1.60(-2) |
| 21                 | 2.68(-3)  | 1.71(-2) | 3.67(-2) | 2.53(-2) | 3.39(-4) | 1.63(-2) | 1.87(-2) | 4.98(-5) | 1.91(-2) | 8.33(-3) | 5.88(-3) |

\*Read as  $1.89 \times 10^{-3}$ .

Table 24. Franck-Condon factors for  $N_2$   $w\ ^1\Delta_u - X\ ^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 2.91(-3)* | 2.04(-2) | 6.67(-2) | 1.37(-1) | 1.95(-1) | 2.07(-1) | 1.70(-1) | 1.10(-1) | 5.67(-2) | 2.37(-2) | 8.04(-3) |
| 1                  | 1.36(-2)  | 6.58(-2) | 1.33(-1) | 1.34(-1) | 5.70(-2) | 5.53(-4) | 3.91(-2) | 1.23(-1) | 1.63(-1) | 1.36(-1) | 8.14(-2) |
| 2                  | 3.40(-2)  | 1.09(-1) | 1.15(-1) | 2.95(-2) | 7.59(-3) | 7.88(-2) | 8.88(-2) | 1.99(-2) | 8.76(-3) | 8.49(-2) | 1.48(-1) |
| 3                  | 6.06(-2)  | 1.19(-1) | 4.70(-2) | 3.81(-3) | 7.14(-2) | 5.65(-2) | 1.22(-4) | 5.00(-2) | 8.56(-2) | 2.57(-2) | 5.82(-3) |
| 4                  | 8.66(-2)  | 9.43(-2) | 2.88(-3) | 4.82(-2) | 5.82(-2) | 7.88(-5) | 5.15(-2) | 5.51(-2) | 3.77(-4) | 4.73(-2) | 7.88(-2) |
| 5                  | 1.05(-1)  | 5.27(-2) | 9.19(-3) | 6.77(-2) | 7.58(-3) | 3.43(-2) | 5.07(-2) | 4.13(-7) | 5.13(-2) | 4.44(-2) | 4.34(-4) |
| 6                  | 1.14(-1)  | 1.74(-2) | 3.95(-2) | 4.05(-2) | 7.11(-3) | 5.56(-2) | 3.17(-3) | 3.87(-2) | 3.74(-2) | 2.71(-3) | 5.78(-2) |
| 7                  | 1.12(-1)  | 9.90(-4) | 5.95(-2) | 7.73(-3) | 3.83(-2) | 2.41(-2) | 1.53(-2) | 4.50(-2) | 8.13(-5) | 4.80(-2) | 1.84(-2) |
| 8                  | 1.02(-1)  | 3.50(-3) | 5.61(-2) | 1.19(-3) | 4.90(-2) | 2.08(-4) | 4.40(-2) | 7.05(-3) | 3.08(-2) | 2.67(-2) | 8.94(-3) |
| 9                  | 8.77(-2)  | 1.76(-2) | 3.67(-2) | 1.78(-2) | 3.01(-2) | 1.30(-2) | 3.33(-2) | 5.79(-3) | 4.01(-2) | 1.85(-4) | 4.30(-2) |
| 10                 | 7.18(-2)  | 3.47(-2) | 1.55(-2) | 3.71(-2) | 6.98(-3) | 3.50(-2) | 6.50(-3) | 3.15(-2) | 1.05(-2) | 2.51(-2) | 2.00(-2) |
| 11                 | 5.65(-2)  | 4.87(-2) | 2.45(-3) | 4.43(-2) | 2.63(-4) | 3.79(-2) | 1.56(-3) | 3.52(-2) | 1.40(-3) | 3.59(-2) | 2.12(-4) |
| 12                 | 4.30(-2)  | 5.66(-2) | 4.87(-4) | 3.74(-2) | 1.03(-2) | 2.22(-2) | 1.77(-2) | 1.51(-2) | 2.07(-2) | 1.33(-2) | 2.04(-2) |
| 13                 | 3.19(-2)  | 5.85(-2) | 7.00(-3) | 2.31(-2) | 2.53(-2) | 5.40(-3) | 3.17(-2) | 5.01(-4) | 3.23(-2) | 2.17(-5) | 3.22(-2) |
| 14                 | 2.31(-2)  | 5.56(-2) | 1.75(-2) | 9.48(-3) | 3.42(-2) | 8.47(-5) | 3.00(-2) | 5.50(-3) | 2.16(-2) | 1.21(-2) | 1.58(-2) |
| 15                 | 1.65(-2)  | 4.96(-2) | 2.78(-2) | 1.51(-3) | 3.34(-2) | 6.68(-3) | 1.69(-2) | 1.98(-2) | 5.01(-3) | 2.66(-2) | 5.86(-4) |

\*Read as  $2.91 \times 10^{-3}$ .

Table 25. Franck-Condon factors for  $N_2 C\ ^3\Pi_u - X\ ^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 5.45(-1)* | 3.47(-1) | 9.28(-2) | 1.39(-2) | 1.34(-3) | 9.78(-5) | 6.49(-6) | 4.30(-7) | 3.19(-8) | 3.59(-9) | 1.09(-9) |
| 1                  | 3.08(-1)  | 7.92(-2) | 3.59(-1) | 1.99(-1) | 4.77(-2) | 6.68(-3) | 6.84(-4) | 6.24(-5) | 5.82(-6) | 6.99(-7) | 7.82(-8) |
| 2                  | 1.06(-1)  | 2.67(-1) | 2.68(-3) | 2.31(-1) | 2.68(-1) | 1.00(-1) | 2.02(-2) | 2.39(-3) | 3.72(-4) | 4.83(-5) | 7.25(-6) |
| 3                  | 3.00(-2)  | 1.83(-1) | 1.28(-1) | 7.49(-2) | 8.80(-2) | 2.73(-1) | 1.63(-1) | 4.78(-2) | 9.74(-3) | 1.76(-3) | 3.05(-4) |
| 4                  | 7.74(-3)  | 7.94(-2) | 1.84(-1) | 2.25(-2) | 1.50(-1) | 5.91(-3) | 2.04(-1) | 2.15(-1) | 9.49(-2) | 2.78(-2) | 6.86(-3) |

\*Read as  $5.45 \times 10^{-1}$ .

Table 26. Franck-Condon factors for  $N_2 E\ ^3\Sigma_g^+ - X\ ^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6         | 7         | 8         | 9         | 10        |
|--------------------|-----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|
| 0                  | 9.29(-1)* | 6.93(-2) | 1.86(-3) | 2.31(-5) | 2.01(-7) | 7.69(-9) | 4.47(-13) | 8.00(-11) | 1.51(-11) | 1.50(-11) | 1.59(-11) |
| 1                  | 6.76(-2)  | 7.93(-1) | 1.33(-1) | 5.75(-3) | 1.07(-4) | 1.38(-6) | 7.07(-8)  | 4.09(-11) | 1.20(-12) | 4.71(-11) | 2.12(-11) |

\*Read as  $9.29 \times 10^{-1}$ .

Table 27. Franck-Condon factors for  $N_2 D\ ^3\Sigma_u^+ - X\ ^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7         | 8         | 9         | 10        |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|
| 0                  | 9.84(-1)* | 1.54(-2) | 4.60(-4) | 2.24(-6) | 2.18(-7) | 2.59(-8) | 5.97(-9) | 4.81(-12) | 3.17(-10) | 5.84(-11) | 2.06(-16) |

\*Read as  $9.84 \times 10^{-1}$ .

Table 28. Franck-Condon factors for  $\text{N}_2^+ X \ ^2\Sigma_g^+ - \text{N}_2 X \ ^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1         | 2        | 3        | 4        | 5        | 6         | 7         | 8         | 9         | 10        |
|--------------------|-----------|-----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|
| 0                  | 9.17(-1)* | 8.02(-2)  | 2.53(-3) | 4.47(-5) | 4.17(-7) | 1.26(-8) | 2.10(-10) | 1.01(-10) | 2.09(-11) | 5.10(-12) | 1.35(-12) |
| 1                  | 7.79(-2)  | 7.60(-1)  | 1.54(-1) | 7.91(-3) | 2.04(-4) | 2.57(-6) | 9.23(-8)  | 1.28(-9)  | 8.14(-10) | 1.83(-10) | 5.16(-11) |
| 2                  | 4.65(-3)  | 1.45(-1)  | 6.12(-1) | 2.21(-1) | 1.65(-2) | 5.84(-4) | 9.55(-6)  | 3.96(-7)  | 4.23(-9)  | 3.74(-9)  | 9.13(-10) |
| 3                  | 2.68(-4)  | 1.38(-2)  | 2.01(-1) | 4.75(-1) | 2.80(-1) | 2.86(-2) | 1.34(-3)  | 2.78(-5)  | 1.31(-6)  | 9.68(-9)  | 1.28(-8)  |
| 4                  | 1.76(-5)  | 1.12(-3)  | 2.72(-2) | 2.44(-1) | 3.51(-1) | 3.29(-1) | 4.46(-2)  | 2.68(-3)  | 6.99(-5)  | 3.66(-6)  | 1.63(-8)  |
| 5                  | 1.55(-6)  | 9.62(-5)  | 2.89(-3) | 4.45(-2) | 2.74(-1) | 2.42(-1) | 3.67(-1)  | 6.46(-2)  | 4.91(-3)  | 1.59(-4)  | 9.21(-6)  |
| 6                  | 2.13(-7)  | 1.06(-5)  | 3.14(-4) | 6.00(-3) | 6.50(-2) | 2.90(-1) | 1.50(-1)  | 3.91(-1)  | 8.87(-2)  | 8.42(-3)  | 3.34(-4)  |
| 7                  | 4.74(-8)  | 1.71(-6)  | 4.18(-5) | 7.97(-4) | 1.08(-2) | 8.78(-2) | 2.91(-1)  | 7.83(-2)  | 4.01(-1)  | 1.17(-1)  | 1.37(-2)  |
| 8                  | 1.47(-8)  | 4.21(-7)  | 7.79(-6) | 1.25(-4) | 1.72(-3) | 1.78(-2) | 1.11(-1)  | 2.76(-1)  | 2.90(-2)  | 3.94(-1)  | 1.48(-1)  |
| 9                  | 5.49(-9)  | 1.42(-7)  | 2.11(-6) | 2.65(-5) | 3.16(-4) | 3.34(-3) | 2.71(-2)  | 1.34(-1)  | 2.47(-1)  | 3.68(-3)  | 3.70(-1)  |
| 10                 | 2.24(-9)  | 5.67(-8)  | 7.58(-7) | 7.79(-6) | 7.48(-5) | 7.01(-4) | 5.94(-3)  | 3.89(-2)  | 1.54(-1)  | 2.05(-1)  | 2.24(-3)  |
| 11                 | 9.69(-10) | 2.50(-8)  | 3.24(-7) | 2.98(-6) | 2.37(-5) | 1.84(-4) | 1.42(-3)  | 9.88(-3)  | 5.30(-2)  | 1.67(-1)  | 1.55(-1)  |
| 12                 | 4.42(-10) | 1.17(-8)  | 1.53(-7) | 1.35(-6) | 9.59(-6) | 6.28(-5) | 4.11(-4)  | 2.66(-3)  | 1.55(-2)  | 6.86(-2)  | 1.71(-1)  |
| 13                 | 2.13(-10) | 5.77(-9)  | 7.65(-8) | 6.73(-7) | 4.56(-6) | 2.67(-5) | 1.50(-4)  | 8.41(-4)  | 4.66(-3)  | 2.30(-2)  | 8.44(-2)  |
| 14                 | 1.10(-10) | 2.99(-9)  | 4.03(-8) | 3.59(-7) | 2.40(-6) | 1.33(-5) | 6.67(-5)  | 3.26(-4)  | 1.61(-3)  | 7.71(-3)  | 3.24(-2)  |
| 15                 | 6.01(-11) | 1.64(-9)  | 2.23(-8) | 2.01(-7) | 1.35(-6) | 7.33(-6) | 3.46(-5)  | 1.52(-4)  | 6.61(-4)  | 2.88(-3)  | 1.21(-2)  |
| 16                 | 3.50(-11) | 9.50(-10) | 1.30(-8) | 1.18(-7) | 7.97(-7) | 4.31(-6) | 1.98(-5)  | 8.17(-5)  | 3.21(-4)  | 1.26(-3)  | 4.88(-3)  |
| 17                 | 2.15(-11) | 5.81(-10) | 7.95(-9) | 7.24(-8) | 4.92(-7) | 2.67(-6) | 1.21(-5)  | 4.85(-5)  | 1.78(-4)  | 6.35(-4)  | 2.24(-3)  |
| 18                 | 1.38(-11) | 3.74(-10) | 5.10(-9) | 4.64(-8) | 3.17(-7) | 1.72(-6) | 7.82(-6)  | 3.07(-5)  | 1.09(-4)  | 3.62(-4)  | 1.18(-3)  |
| 19                 | 9.28(-12) | 2.52(-10) | 3.42(-9) | 3.10(-8) | 2.12(-7) | 1.15(-6) | 5.24(-6)  | 2.05(-5)  | 7.11(-5)  | 2.27(-4)  | 6.91(-4)  |
| 20                 | 6.50(-12) | 1.77(-10) | 2.39(-9) | 2.16(-8) | 1.47(-7) | 8.01(-7) | 3.64(-6)  | 1.42(-5)  | 4.88(-5)  | 1.52(-4)  | 4.42(-4)  |
| 21                 | 4.74(-12) | 1.29(-10) | 1.73(-9) | 1.56(-8) | 1.06(-7) | 5.74(-7) | 2.61(-6)  | 1.02(-5)  | 3.47(-5)  | 1.07(-4)  | 3.02(-4)  |

\*Read as  $9.17 \times 10^{-1}$ .

Table 29. Franck-Condon factors for  $\text{N}_2^+ A^2\Pi_u - \text{N}_2 X^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 2.64(-1)* | 3.79(-1) | 2.41(-1) | 8.98(-2) | 2.19(-2) | 3.68(-3) | 4.39(-4) | 3.78(-5) | 2.37(-6) | 1.08(-7) | 3.50(-9) |
| 1                  | 3.18(-1)  | 2.97(-2) | 1.03(-1) | 2.67(-1) | 1.92(-1) | 7.15(-2) | 1.64(-2) | 2.52(-3) | 2.68(-4) | 2.01(-5) | 1.07(-6) |
| 2                  | 2.19(-1)  | 5.01(-2) | 1.60(-1) | 5.57(-5) | 1.49(-1) | 2.35(-1) | 1.35(-1) | 4.20(-2) | 8.16(-3) | 1.06(-3) | 9.39(-5) |
| 3                  | 1.15(-1)  | 1.57(-1) | 1.02(-2) | 1.30(-1) | 5.76(-2) | 3.60(-2) | 2.04(-1) | 1.89(-1) | 7.97(-2) | 1.95(-2) | 3.06(-3) |
| 4                  | 5.09(-2)  | 1.62(-1) | 3.45(-2) | 8.45(-2) | 3.70(-2) | 1.21(-1) | 1.44(-4) | 1.27(-1) | 2.12(-1) | 1.24(-1) | 3.83(-2) |
| 5                  | 2.04(-2)  | 1.11(-1) | 1.09(-1) | 1.39(-3) | 1.13(-1) | 3.09(-5) | 1.18(-1) | 3.21(-2) | 4.98(-2) | 1.98(-1) | 1.65(-1) |
| 6                  | 7.70(-3)  | 6.07(-2) | 1.25(-1) | 3.31(-2) | 4.20(-2) | 7.32(-2) | 2.94(-2) | 6.62(-2) | 8.35(-2) | 5.41(-3) | 1.52(-1) |
| 7                  | 2.80(-3)  | 2.92(-2) | 9.57(-2) | 8.74(-2) | 1.29(-4) | 8.27(-2) | 1.95(-2) | 7.43(-2) | 1.54(-2) | 1.11(-1) | 4.94(-3) |
| 8                  | 1.00(-3)  | 1.30(-2) | 5.92(-2) | 1.01(-1) | 3.34(-2) | 1.88(-2) | 8.08(-2) | 1.25(-4) | 8.95(-2) | 4.48(-4) | 9.89(-2) |
| 9                  | 3.58(-4)  | 5.51(-3) | 3.21(-2) | 8.22(-2) | 7.35(-2) | 2.05(-3) | 5.47(-2) | 4.49(-2) | 2.06(-2) | 6.64(-2) | 2.22(-2) |
| 10                 | 1.29(-4)  | 2.28(-3) | 1.61(-2) | 5.50(-2) | 8.41(-2) | 3.28(-2) | 7.38(-3) | 7.12(-2) | 9.57(-3) | 5.39(-2) | 2.78(-2) |
| 11                 | 4.76(-5)  | 9.33(-4) | 7.66(-3) | 3.26(-2) | 7.11(-2) | 6.31(-2) | 4.45(-3) | 3.44(-2) | 5.65(-2) | 7.75(-4) | 6.98(-2) |
| 12                 | 1.80(-5)  | 3.84(-4) | 3.55(-3) | 1.79(-2) | 5.05(-2) | 7.14(-2) | 3.11(-2) | 2.43(-3) | 5.66(-2) | 2.57(-2) | 1.90(-2) |
| 13                 | 7.03(-6)  | 1.60(-4) | 1.62(-3) | 9.36(-3) | 3.21(-2) | 6.22(-2) | 5.44(-2) | 6.20(-3) | 2.14(-2) | 5.65(-2) | 3.07(-3) |
| 14                 | 2.84(-6)  | 6.79(-5) | 7.44(-4) | 4.76(-3) | 1.90(-2) | 4.63(-2) | 6.13(-2) | 2.85(-2) | 6.08(-4) | 4.32(-2) | 3.61(-2) |
| 15                 | 1.18(-6)  | 2.95(-5) | 3.43(-4) | 2.39(-3) | 1.08(-2) | 3.13(-2) | 5.49(-2) | 4.70(-2) | 6.98(-3) | 1.35(-2) | 5.09(-2) |
| 16                 | 5.10(-7)  | 1.32(-5) | 1.60(-4) | 1.20(-3) | 5.93(-3) | 1.98(-2) | 4.28(-2) | 5.30(-2) | 2.55(-2) | 8.57(-5) | 3.28(-2) |
| 17                 | 2.26(-7)  | 6.01(-6) | 7.62(-5) | 6.01(-4) | 3.22(-3) | 1.20(-2) | 3.04(-2) | 4.89(-2) | 4.05(-2) | 6.94(-3) | 8.97(-3) |
| 18                 | 1.03(-7)  | 2.81(-6) | 3.69(-5) | 3.04(-4) | 1.74(-3) | 7.08(-3) | 2.04(-2) | 3.97(-2) | 4.62(-2) | 2.22(-2) | 6.74(-7) |
| 19                 | 4.75(-8)  | 1.34(-6) | 1.81(-5) | 1.56(-4) | 9.38(-4) | 4.11(-3) | 1.31(-2) | 2.96(-2) | 4.38(-2) | 3.47(-2) | 6.32(-3) |
| 20                 | 2.23(-8)  | 6.48(-7) | 9.06(-6) | 8.07(-5) | 5.08(-4) | 2.37(-3) | 8.21(-3) | 2.09(-2) | 3.69(-2) | 4.03(-2) | 1.89(-2) |
| 21                 | 1.05(-8)  | 3.17(-7) | 4.58(-6) | 4.22(-5) | 2.77(-4) | 1.36(-3) | 5.05(-3) | 1.42(-2) | 2.88(-2) | 3.93(-2) | 2.96(-2) |

\*Read as  $2.64 \times 10^{-1}$ .

Table 30. Franck-Condon factors for  $\text{N}_2^+ \ B \ ^2\Sigma_u^+ - \text{N}_2 \ X \ ^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0         | 1         | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 8.83(-1)* | 1.04(-1)  | 1.18(-2) | 1.21(-3) | 1.27(-4) | 1.35(-5) | 1.48(-6) | 1.64(-7) | 1.99(-8) | 3.43(-9) | 1.25(-9) |
| 1                  | 1.14(-1)  | 6.91(-1)  | 1.61(-1) | 2.86(-2) | 3.93(-3) | 5.17(-4) | 6.63(-5) | 8.64(-6) | 1.18(-6) | 1.89(-7) | 4.56(-8) |
| 2                  | 2.31(-3)  | 2.00(-1)  | 5.57(-1) | 1.86(-1) | 4.59(-2) | 7.81(-3) | 1.25(-3) | 1.88(-4) | 2.91(-5) | 4.86(-6) | 1.01(-6) |
| 3                  | 1.41(-5)  | 4.85(-3)  | 2.64(-1) | 4.69(-1) | 1.87(-1) | 6.12(-2) | 1.22(-2) | 2.33(-3) | 4.08(-4) | 7.46(-5) | 1.52(-5) |
| 4                  | 4.32(-6)  | 1.32(-4)  | 6.01(-3) | 3.09(-1) | 4.19(-1) | 1.71(-1) | 7.37(-2) | 1.65(-2) | 3.74(-3) | 7.46(-4) | 1.62(-4) |
| 5                  | 8.23(-10) | 1.97(-5)  | 5.92(-4) | 4.91(-3) | 3.39(-1) | 4.00(-1) | 1.45(-1) | 8.41(-2) | 2.00(-2) | 5.44(-3) | 1.22(-3) |
| 6                  | 1.27(-8)  | 2.28(-7)  | 4.48(-5) | 1.81(-3) | 1.99(-3) | 3.51(-1) | 4.09(-1) | 1.10(-1) | 9.41(-2) | 2.18(-2) | 7.48(-3) |
| 7                  | 1.25(-11) | 8.34(-8)  | 3.13(-6) | 5.44(-5) | 4.25(-3) | 5.49(-6) | 3.41(-1) | 4.41(-1) | 7.14(-2) | 1.07(-1) | 2.12(-2) |
| 8                  | 1.59(-10) | 1.80(-9)  | 1.99(-7) | 1.92(-5) | 1.59(-5) | 7.92(-3) | 5.47(-3) | 3.01(-1) | 4.88(-1) | 3.43(-2) | 1.26(-1) |
| 9                  | 4.98(-11) | 1.47(-9)  | 3.08(-8) | 5.59(-8) | 7.07(-5) | 4.91(-5) | 1.14(-2) | 2.93(-2) | 2.23(-1) | 5.32(-1) | 7.61(-3) |
| 10                 | 1.50(-11) | 7.92(-10) | 4.18(-9) | 2.10(-7) | 1.24(-6) | 1.62(-4) | 8.63(-4) | 1.12(-2) | 8.25(-2) | 1.17(-1) | 5.36(-1) |

\*Read as  $8.83 \times 10^{-1}$ .

Table 31. Franck-Condon factors for  $\text{N}_2^+ C\ ^2\Sigma_u^+ - \text{N}_2 X\ ^1\Sigma_g^+$ .

| $v' \setminus v''$ | 0          | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 2.75(-3) * | 2.17(-2) | 7.78(-2) | 1.66(-1) | 2.35(-1) | 2.30(-1) | 1.59(-1) | 7.68(-2) | 2.53(-2) | 5.34(-3) | 6.29(-4) |
| 1                  | 1.40(-2)   | 7.33(-2) | 1.50(-1) | 1.36(-1) | 3.42(-2) | 8.96(-3) | 1.15(-1) | 2.01(-1) | 1.66(-1) | 7.77(-2) | 2.09(-2) |
| 2                  | 3.73(-2)   | 1.22(-1) | 1.18(-1) | 1.53(-2) | 3.04(-2) | 1.07(-1) | 4.67(-2) | 5.85(-3) | 1.21(-1) | 2.01(-1) | 1.39(-1) |
| 3                  | 6.87(-2)   | 1.30(-1) | 3.56(-2) | 1.71(-2) | 8.75(-2) | 2.08(-2) | 2.63(-2) | 9.44(-2) | 2.07(-2) | 3.40(-2) | 1.77(-1) |
| 4                  | 9.91(-2)   | 9.35(-2) | 3.38(-7) | 6.96(-2) | 3.24(-2) | 1.70(-2) | 7.22(-2) | 3.99(-3) | 5.41(-2) | 7.01(-2) | 2.51(-4) |
| 5                  | 1.19(-1)   | 4.32(-2) | 2.39(-2) | 6.27(-2) | 6.86(-4) | 6.27(-2) | 9.42(-3) | 4.03(-2) | 4.46(-2) | 7.09(-3) | 8.25(-2) |
| 6                  | 1.25(-1)   | 8.42(-3) | 5.81(-2) | 1.90(-2) | 3.39(-2) | 3.30(-2) | 1.52(-2) | 4.89(-2) | 1.94(-3) | 6.08(-2) | 4.28(-3) |
| 7                  | 1.18(-1)   | 3.92(-4) | 6.53(-2) | 3.59(-5) | 5.43(-2) | 3.63(-4) | 4.93(-2) | 3.08(-3) | 4.46(-2) | 1.12(-2) | 3.65(-2) |
| 8                  | 1.03(-1)   | 1.26(-2) | 4.58(-2) | 1.61(-2) | 3.33(-2) | 1.66(-2) | 2.99(-2) | 1.52(-2) | 3.16(-2) | 1.21(-2) | 3.80(-2) |
| 9                  | 8.35(-2)   | 3.23(-2) | 1.97(-2) | 3.93(-2) | 6.08(-3) | 4.06(-2) | 1.83(-3) | 4.05(-2) | 5.99(-4) | 4.11(-2) | 4.08(-4) |
| 10                 | 6.46(-2)   | 4.92(-2) | 3.12(-3) | 4.69(-2) | 1.18(-3) | 3.66(-2) | 7.73(-3) | 2.69(-2) | 1.47(-2) | 2.00(-2) | 2.04(-2) |

\*Read as  $2.75 \times 10^{-3}$ .

Table 32. Franck-Condon factors for  $O_2^+ X ^2\Pi_g - O_2 X ^3\Sigma_g^-$ .

| $v' \setminus v''$ | 0         | 1         | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9        | 10       |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|
| 0                  | 1.86(-1)* | 2.71(-1)  | 2.30(-1)  | 1.50(-1)  | 8.40(-2)  | 4.24(-2)  | 2.00(-2)  | 9.02(-3)  | 3.94(-3)  | 1.69(-3) | 7.15(-4) |
| 1                  | 3.62(-1)  | 8.32(-2)  | 4.96(-3)  | 8.33(-2)  | 1.34(-1)  | 1.25(-1)  | 8.98(-2)  | 5.53(-2)  | 3.09(-2)  | 1.61(-2) | 8.02(-3) |
| 2                  | 2.91(-1)  | 4.27(-2)  | 1.65(-1)  | 5.34(-2)  | 5.55(-4)  | 4.41(-2)  | 8.95(-2)  | 9.82(-2)  | 8.08(-2)  | 5.61(-2) | 3.49(-2) |
| 3                  | 1.25(-1)  | 2.57(-1)  | 1.65(-2)  | 7.24(-2)  | 1.09(-1)  | 3.10(-2)  | 6.16(-4)  | 3.16(-2)  | 6.73(-2)  | 7.91(-2) | 7.03(-2) |
| 4                  | 3.07(-2)  | 2.36(-1)  | 1.10(-1)  | 9.65(-2)  | 4.15(-3)  | 8.21(-2)  | 7.44(-2)  | 1.64(-2)  | 1.38(-3)  | 2.65(-2) | 5.45(-2) |
| 5                  | 4.33(-3)  | 9.10(-2)  | 2.67(-1)  | 1.57(-2)  | 1.28(-1)  | 1.32(-2)  | 2.82(-2)  | 7.66(-2)  | 4.89(-2)  | 7.60(-3) | 2.61(-3) |
| 6                  | 3.26(-4)  | 1.73(-2)  | 1.61(-1)  | 2.25(-1)  | 3.47(-3)  | 9.76(-2)  | 5.42(-2)  | 8.73(-4)  | 4.67(-2)  | 6.33(-2) | 3.07(-2) |
| 7                  | 1.07(-5)  | 1.60(-3)  | 4.06(-2)  | 2.20(-1)  | 1.51(-1)  | 3.89(-2)  | 4.65(-2)  | 8.08(-2)  | 8.67(-3)  | 1.48(-2) | 5.28(-2) |
| 8                  | 7.14(-8)  | 5.94(-5)  | 4.53(-3)  | 7.29(-2)  | 2.57(-1)  | 7.87(-2)  | 8.09(-2)  | 1.00(-2)  | 7.83(-2)  | 3.31(-2) | 3.60(-4) |
| 9                  | 7.16(-10) | 3.47(-7)  | 1.85(-4)  | 9.65(-3)  | 1.11(-1)  | 2.67(-1)  | 2.80(-2)  | 1.06(-1)  | 1.33(-4)  | 5.54(-2) | 5.37(-2) |
| 10                 | 4.25(-11) | 8.65(-9)  | 8.54(-7)  | 4.22(-4)  | 1.72(-2)  | 1.51(-1)  | 2.57(-1)  | 3.57(-3)  | 1.07(-1)  | 1.14(-2) | 2.80(-2) |
| 11                 | 2.46(-13) | 3.23(-10) | 5.21(-8)  | 1.32(-6)  | 7.91(-4)  | 2.70(-2)  | 1.91(-1)  | 2.31(-1)  | 1.23(-3)  | 9.15(-2) | 3.18(-2) |
| 12                 | 2.10(-14) | 6.10(-12) | 1.19(-9)  | 2.13(-7)  | 1.21(-6)  | 1.28(-3)  | 3.89(-2)  | 2.26(-1)  | 1.98(-1)  | 1.30(-2) | 6.71(-2) |
| 13                 | 7.65(-16) | 2.04(-13) | 5.31(-11) | 2.68(-9)  | 6.66(-7)  | 3.72(-7)  | 1.84(-3)  | 5.21(-2)  | 2.58(-1)  | 1.62(-1) | 3.10(-2) |
| 14                 | 8.53(-16) | 1.66(-14) | 7.48(-13) | 3.02(-10) | 3.67(-9)  | 1.70(-6)  | 2.56(-7)  | 2.40(-3)  | 6.62(-2)  | 2.84(-1) | 1.30(-1) |
| 15                 | 6.53(-16) | 4.35(-17) | 1.35(-13) | 8.80(-13) | 1.23(-9)  | 1.96(-9)  | 3.70(-6)  | 5.83(-6)  | 2.86(-3)  | 8.03(-2) | 3.07(-1) |
| 16                 | 2.09(-15) | 1.28(-17) | 6.77(-17) | 8.09(-13) | 4.23(-17) | 3.90(-9)  | 4.34(-10) | 6.94(-6)  | 2.76(-5)  | 3.12(-3) | 9.38(-2) |
| 17                 | 3.66(-16) | 1.93(-18) | 5.85(-16) | 1.34(-14) | 3.46(-12) | 1.32(-11) | 9.97(-9)  | 2.74(-8)  | 1.14(-5)  | 8.32(-5) | 3.07(-3) |
| 18                 | 4.26(-16) | 4.23(-17) | 7.54(-17) | 6.24(-17) | 1.28(-13) | 9.64(-12) | 1.55(-10) | 2.07(-8)  | 1.80(-7)  | 1.62(-5) | 1.97(-4) |
| 19                 | 1.44(-15) | 8.81(-17) | 4.29(-16) | 9.12(-19) | 2.47(-15) | 7.26(-13) | 1.94(-11) | 8.78(-10) | 3.40(-8)  | 6.92(-7) | 1.97(-5) |
| 20                 | 5.52(-16) | 1.88(-17) | 1.82(-16) | 1.13(-18) | 3.38(-15) | 5.89(-16) | 3.52(-12) | 2.30(-11) | 3.47(-9)  | 4.17(-8) | 1.99(-6) |
| 21                 | 3.76(-17) | 1.38(-17) | 3.02(-18) | 5.31(-17) | 3.47(-16) | 6.02(-15) | 2.49(-14) | 1.22(-11) | 5.30(-12) | 1.06(-8) | 3.01(-8) |

\*Read as  $1.86 \times 10^{-1}$ .

Table 33. Franck-Condon factors for  $O_2^+ a^4\Pi_u - O_2 X^3\Sigma_g^-$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 9.87(-3)* | 5.44(-2) | 1.38(-1) | 2.15(-1) | 2.30(-1) | 1.78(-1) | 1.05(-1) | 4.72(-2) | 1.67(-2) | 4.64(-3) | 1.02(-3) |
| 1                  | 3.60(-2)  | 1.24(-1) | 1.58(-1) | 7.32(-2) | 5.34(-4) | 5.30(-2) | 1.52(-1) | 1.79(-1) | 1.29(-1) | 6.44(-2) | 2.36(-2) |
| 2                  | 7.20(-2)  | 1.42(-1) | 6.01(-2) | 2.33(-3) | 8.29(-2) | 9.51(-2) | 1.32(-2) | 2.37(-2) | 1.23(-1) | 1.68(-1) | 1.26(-1) |
| 3                  | 1.05(-1)  | 1.02(-1) | 1.25(-3) | 6.30(-2) | 6.98(-2) | 2.02(-4) | 6.16(-2) | 8.79(-2) | 1.21(-2) | 2.59(-2) | 1.25(-1) |
| 4                  | 1.24(-1)  | 4.61(-2) | 1.98(-2) | 7.67(-2) | 3.27(-3) | 5.10(-2) | 5.84(-2) | 1.05(-4) | 6.65(-2) | 7.39(-2) | 3.35(-3) |
| 5                  | 1.28(-1)  | 8.65(-3) | 5.79(-2) | 3.11(-2) | 2.03(-2) | 6.08(-2) | 8.72(-5) | 5.84(-2) | 3.89(-2) | 6.08(-3) | 7.94(-2) |
| 6                  | 1.18(-1)  | 4.45(-4) | 6.88(-2) | 8.06(-4) | 5.57(-2) | 1.17(-2) | 3.51(-2) | 4.08(-2) | 5.33(-3) | 6.58(-2) | 1.44(-2) |
| 7                  | 1.01(-1)  | 1.30(-2) | 5.05(-2) | 1.08(-2) | 4.68(-2) | 4.05(-3) | 5.21(-2) | 1.12(-4) | 5.15(-2) | 1.48(-2) | 2.72(-2) |
| 8                  | 8.17(-2)  | 3.27(-2) | 2.34(-2) | 3.57(-2) | 1.54(-2) | 3.24(-2) | 1.90(-2) | 2.44(-2) | 3.15(-2) | 1.05(-2) | 5.02(-2) |
| 9                  | 6.29(-2)  | 4.94(-2) | 4.83(-3) | 4.86(-2) | 9.09(-5) | 4.46(-2) | 6.92(-6) | 4.40(-2) | 3.33(-4) | 4.43(-2) | 5.12(-3) |
| 10                 | 4.67(-2)  | 5.87(-2) | 1.05(-4) | 4.30(-2) | 8.32(-3) | 2.92(-2) | 1.47(-2) | 2.43(-2) | 1.61(-2) | 2.68(-2) | 1.25(-2) |
| 11                 | 3.38(-2)  | 6.05(-2) | 5.99(-3) | 2.72(-2) | 2.53(-2) | 8.21(-3) | 3.33(-2) | 2.22(-3) | 3.60(-2) | 1.03(-3) | 3.79(-2) |
| 12                 | 2.40(-2)  | 5.67(-2) | 1.64(-2) | 1.16(-2) | 3.61(-2) | 5.45(-7) | 3.38(-2) | 3.93(-3) | 2.77(-2) | 9.12(-3) | 2.48(-2) |
| 13                 | 1.68(-2)  | 4.97(-2) | 2.65(-2) | 2.28(-3) | 3.59(-2) | 5.95(-3) | 1.99(-2) | 1.94(-2) | 7.79(-3) | 2.75(-2) | 2.63(-3) |
| 14                 | 1.16(-2)  | 4.16(-2) | 3.34(-2) | 5.70(-5) | 2.76(-2) | 1.75(-2) | 5.73(-3) | 2.92(-2) | 2.88(-5) | 2.84(-2) | 3.65(-3) |
| 15                 | 8.05(-3)  | 3.36(-2) | 3.66(-2) | 2.90(-3) | 1.68(-2) | 2.64(-2) | 3.90(-5) | 2.65(-2) | 7.24(-3) | 1.45(-2) | 1.84(-2) |
| 16                 | 5.58(-3)  | 2.66(-2) | 3.66(-2) | 8.05(-3) | 7.76(-3) | 2.90(-2) | 2.99(-3) | 1.62(-2) | 1.85(-2) | 2.36(-3) | 2.57(-2) |
| 17                 | 3.88(-3)  | 2.07(-2) | 3.44(-2) | 1.33(-2) | 2.19(-3) | 2.61(-2) | 1.01(-2) | 6.04(-3) | 2.43(-2) | 5.91(-4) | 1.99(-2) |
| 18                 | 2.72(-3)  | 1.60(-2) | 3.10(-2) | 1.75(-2) | 9.01(-5) | 2.02(-2) | 1.70(-2) | 6.51(-4) | 2.24(-2) | 6.90(-3) | 8.90(-3) |
| 19                 | 1.93(-3)  | 1.22(-2) | 2.71(-2) | 2.01(-2) | 4.92(-4) | 1.36(-2) | 2.10(-2) | 4.82(-4) | 1.57(-2) | 1.47(-2) | 1.36(-3) |
| 20                 | 1.38(-3)  | 9.41(-3) | 2.31(-2) | 2.12(-2) | 2.27(-3) | 7.89(-3) | 2.17(-2) | 3.68(-3) | 8.32(-3) | 1.93(-2) | 3.43(-4) |
| 21                 | 1.00(-3)  | 7.24(-3) | 1.95(-2) | 2.11(-2) | 4.51(-3) | 3.82(-3) | 1.99(-2) | 7.94(-3) | 2.92(-3) | 1.93(-2) | 4.09(-3) |

\*Read as  $9.87 \times 10^{-3}$ .

Table 34. Franck-Condon factors for  $O_2^+ A^2\Pi_u - O_2 X^3\Sigma_g^-$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 2.84(-3)* | 1.95(-2) | 6.34(-2) | 1.29(-1) | 1.86(-1) | 2.02(-1) | 1.71(-1) | 1.16(-1) | 6.43(-2) | 2.96(-2) | 1.14(-2) |
| 1                  | 1.23(-2)  | 6.00(-2) | 1.23(-1) | 1.31(-1) | 6.34(-2) | 3.00(-3) | 2.49(-2) | 1.01(-1) | 1.53(-1) | 1.44(-1) | 9.88(-2) |
| 2                  | 2.91(-2)  | 9.71(-2) | 1.12(-1) | 3.73(-2) | 2.21(-3) | 6.22(-2) | 9.25(-2) | 3.75(-2) | 1.83(-4) | 4.74(-2) | 1.20(-1) |
| 3                  | 5.00(-2)  | 1.09(-1) | 5.50(-2) | 2.40(-4) | 5.50(-2) | 6.71(-2) | 6.89(-3) | 2.34(-2) | 8.04(-2) | 5.52(-2) | 2.58(-3) |
| 4                  | 6.97(-2)  | 9.23(-2) | 9.74(-3) | 2.92(-2) | 6.44(-2) | 7.34(-3) | 2.56(-2) | 6.55(-2) | 1.65(-2) | 1.11(-2) | 6.95(-2) |
| 5                  | 8.43(-2)  | 6.11(-2) | 1.01(-3) | 5.70(-2) | 2.39(-2) | 1.05(-2) | 5.65(-2) | 1.30(-2) | 1.64(-2) | 6.05(-2) | 1.90(-2) |
| 6                  | 9.18(-2)  | 3.04(-2) | 1.75(-2) | 5.14(-2) | 2.34(-4) | 4.23(-2) | 2.51(-2) | 6.96(-3) | 5.10(-2) | 1.26(-2) | 1.54(-2) |
| 7                  | 9.25(-2)  | 9.51(-3) | 3.75(-2) | 2.65(-2) | 1.10(-2) | 4.30(-2) | 1.92(-4) | 3.82(-2) | 2.10(-2) | 8.24(-3) | 4.78(-2) |
| 8                  | 8.78(-2)  | 6.28(-4) | 4.74(-2) | 5.82(-3) | 3.12(-2) | 1.89(-2) | 1.27(-2) | 3.60(-2) | 7.87(-5) | 3.83(-2) | 1.45(-2) |
| 9                  | 7.97(-2)  | 1.43(-3) | 4.49(-2) | 8.80(-5) | 3.87(-2) | 1.54(-3) | 3.19(-2) | 1.08(-2) | 1.77(-2) | 2.84(-2) | 1.83(-3) |
| 10                 | 6.98(-2)  | 7.88(-3) | 3.44(-2) | 6.46(-3) | 3.09(-2) | 2.85(-3) | 3.26(-2) | 3.67(-5) | 3.27(-2) | 3.84(-3) | 2.41(-2) |
| 11                 | 5.96(-2)  | 1.63(-2) | 2.15(-2) | 1.70(-2) | 1.67(-2) | 1.46(-2) | 1.85(-2) | 9.44(-3) | 2.43(-2) | 2.90(-3) | 3.06(-2) |
| 12                 | 4.99(-2)  | 2.42(-2) | 1.06(-2) | 2.54(-2) | 5.10(-3) | 2.46(-2) | 4.77(-3) | 2.23(-2) | 7.55(-3) | 1.76(-2) | 1.43(-2) |
| 13                 | 4.12(-2)  | 3.03(-2) | 3.48(-3) | 2.88(-2) | 1.90(-4) | 2.68(-2) | 6.14(-7) | 2.58(-2) | 3.10(-5) | 2.54(-2) | 9.47(-4) |
| 14                 | 3.36(-2)  | 3.40(-2) | 3.24(-4) | 2.73(-2) | 1.35(-3) | 2.21(-2) | 3.62(-3) | 1.96(-2) | 4.21(-3) | 1.98(-2) | 2.89(-3) |
| 15                 | 2.72(-2)  | 3.57(-2) | 3.30(-4) | 2.26(-2) | 5.86(-3) | 1.42(-2) | 1.05(-2) | 9.97(-3) | 1.27(-2) | 8.77(-3) | 1.25(-2) |
| 16                 | 2.19(-2)  | 3.56(-2) | 2.37(-3) | 1.67(-2) | 1.10(-2) | 6.91(-3) | 1.61(-2) | 2.70(-3) | 1.82(-2) | 1.30(-3) | 1.88(-2) |
| 17                 | 1.76(-2)  | 3.42(-2) | 5.40(-3) | 1.09(-2) | 1.49(-2) | 2.07(-3) | 1.82(-2) | 2.64(-5) | 1.83(-2) | 3.51(-4) | 1.77(-2) |
| 18                 | 1.41(-2)  | 3.19(-2) | 8.62(-3) | 6.18(-3) | 1.68(-2) | 1.07(-4) | 1.69(-2) | 1.23(-3) | 1.42(-2) | 3.92(-3) | 1.17(-2) |
| 19                 | 1.13(-2)  | 2.92(-2) | 1.15(-2) | 2.87(-3) | 1.69(-2) | 4.03(-4) | 1.36(-2) | 4.35(-3) | 8.80(-3) | 8.51(-3) | 5.34(-3) |
| 20                 | 9.07(-3)  | 2.62(-2) | 1.37(-2) | 9.25(-4) | 1.55(-2) | 2.00(-3) | 9.53(-3) | 7.56(-3) | 4.12(-3) | 1.16(-2) | 1.23(-3) |
| 21                 | 7.24(-3)  | 2.31(-2) | 1.51(-2) | 9.62(-5) | 1.32(-2) | 3.98(-3) | 5.81(-3) | 9.72(-3) | 1.19(-3) | 1.24(-2) | 3.85(-8) |

\*Read as  $2.84 \times 10^{-3}$ .

Table 35. Franck-Condon factors for  $O_2^+ b\ ^4\Sigma_g^- - O_2 X\ ^3\Sigma_g^-$ .

| $v' \setminus v''$ | 0         | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       |
|--------------------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 0                  | 4.11(-1)* | 3.76(-1) | 1.61(-1) | 4.31(-2) | 8.21(-3) | 1.19(-3) | 1.36(-4) | 1.25(-5) | 9.81(-7) | 6.34(-8) | 3.54(-9) |
| 1                  | 3.36(-1)  | 2.78(-3) | 2.34(-1) | 2.61(-1) | 1.23(-1) | 3.49(-2) | 6.96(-3) | 1.05(-3) | 1.24(-4) | 1.20(-5) | 9.46(-7) |
| 2                  | 1.62(-1)  | 1.69(-1) | 8.18(-2) | 4.85(-2) | 2.31(-1) | 1.96(-1) | 8.31(-2) | 2.25(-2) | 4.43(-3) | 6.62(-4) | 7.88(-5) |
| 3                  | 6.13(-2)  | 2.09(-1) | 1.69(-2) | 1.62(-1) | 2.55(-3) | 1.20(-1) | 2.18(-1) | 1.41(-1) | 5.28(-2) | 1.34(-2) | 2.52(-3) |
| 4                  | 2.04(-2)  | 1.35(-1) | 1.28(-1) | 1.65(-2) | 1.19(-1) | 6.44(-2) | 2.25(-2) | 1.72(-1) | 1.85(-1) | 9.65(-2) | 3.20(-2) |
| 5                  | 6.36(-3)  | 6.53(-2) | 1.54(-1) | 2.90(-2) | 8.59(-2) | 3.20(-2) | 1.22(-1) | 3.27(-3) | 8.54(-2) | 1.87(-1) | 1.43(-1) |
| 6                  | 1.93(-3)  | 2.72(-2) | 1.11(-1) | 1.05(-1) | 1.43(-3) | 1.12(-1) | 6.48(-4) | 1.06(-1) | 5.10(-2) | 1.50(-2) | 1.40(-1) |
| 7                  | 5.83(-4)  | 1.04(-2) | 6.15(-2) | 1.22(-1) | 3.39(-2) | 4.24(-2) | 6.72(-2) | 3.97(-2) | 4.17(-2) | 1.00(-1) | 3.59(-3) |
| 8                  | 1.79(-4)  | 3.83(-3) | 2.97(-2) | 9.34(-2) | 8.80(-2) | 1.07(-4) | 8.40(-2) | 1.09(-2) | 8.46(-2) | 8.29(-4) | 9.49(-2) |
| 9                  | 5.60(-5)  | 1.38(-3) | 1.32(-2) | 5.74(-2) | 1.00(-1) | 3.29(-2) | 2.21(-2) | 7.33(-2) | 5.35(-3) | 7.60(-2) | 2.03(-2) |
| 10                 | 1.80(-5)  | 5.01(-4) | 5.63(-3) | 3.11(-2) | 8.12(-2) | 7.29(-2) | 9.22(-4) | 6.11(-2) | 2.59(-2) | 4.48(-2) | 2.71(-2) |
| 11                 | 5.96(-6)  | 1.83(-4) | 2.35(-3) | 1.56(-2) | 5.44(-2) | 8.41(-2) | 2.82(-2) | 1.36(-2) | 6.61(-2) | 2.73(-6) | 6.94(-2) |
| 12                 | 2.00(-6)  | 6.74(-5) | 9.68(-4) | 7.52(-3) | 3.25(-2) | 7.21(-2) | 5.91(-2) | 9.75(-4) | 4.70(-2) | 3.11(-2) | 2.21(-2) |
| 13                 | 6.79(-7)  | 2.51(-5) | 3.99(-4) | 3.52(-3) | 1.81(-2) | 5.23(-2) | 7.06(-2) | 2.14(-2) | 1.10(-2) | 5.61(-2) | 1.18(-3) |
| 14                 | 2.27(-7)  | 9.39(-6) | 1.65(-4) | 1.62(-3) | 9.66(-3) | 3.42(-2) | 6.46(-2) | 4.60(-2) | 3.30(-4) | 3.93(-2) | 2.86(-2) |
| 15                 | 7.20(-8)  | 3.47(-6) | 6.78(-5) | 7.42(-4) | 5.00(-3) | 2.09(-2) | 5.07(-2) | 5.83(-2) | 1.38(-2) | 1.15(-2) | 4.66(-2) |

\*Read as  $4.11 \times 10^{-1}$ .

Table 36. Band origin wavelengths and Einstein coefficients for  $N_2 b^1\Pi_u - X^1\Sigma_g^+$ . For each  $v'-v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ) and  $A_{v'v''}$  ( $\text{s}^{-1}$ ). Band origins from Carroll and Collins (1969) and Roncin *et al.* (1987). Einstein coefficients calculated by normalizing relative band intensities measured by James *et al.* (1990) to the  $v' = 1$  lifetime of 1.75 ns measured by Oertel *et al.* (1981), corrected to a radiative lifetime of 1.96 ns by allowing for 10.5% predissociation as determined by James *et al.* The other levels of the  $b^1\Pi_u$  state are strongly predissociated and give little emission.

| $v' \setminus v''$ | 0                  | 1                 | 2                 | 3                | 4                | 5                | 6           | 7           | 8                | 9                | 10                | 11                | 12             |
|--------------------|--------------------|-------------------|-------------------|------------------|------------------|------------------|-------------|-------------|------------------|------------------|-------------------|-------------------|----------------|
| 1                  | 0.0986<br>1.04(8)* | 0.1009<br>1.04(8) | 0.1033<br>1.21(8) | 0.1058<br>7.1(7) | 0.1083<br>3.9(7) | 0.1110<br>1.5(7) | 0.1138<br>† | 0.1166<br>† | 0.1196<br>1.4(7) | 0.1227<br>1.4(7) | 0.1259<br>1.05(7) | 0.1292<br>1.05(7) | 0.1326<br>8(6) |

\*Read as  $1.04 \times 10^8$ .

†These bands were too weak to be measured by James *et al.* (1990).

Table 37. Band origin wavelengths and Einstein coefficients for  $N_2 c'_4 \ ^1\Sigma_u^+ - X \ ^1\Sigma_g^+$ . For each  $v' - v''$  band, the listed quantities are  $\lambda_{v'v''}$  ( $\mu\text{m}$ ) and  $A_{v'v''}$  ( $\text{s}^{-1}$ ). Band origins from Yoshino and Tanaka (1977) and Roncin *et al.* (1987), or calculated from data therein. Einstein coefficients for  $v'' = 0$  from Table VII of Ajello *et al.* (1989). Einstein coefficients for  $v'' > 0$  from relative band intensities,  $I_{v'v''}/I_{v'0}$ , measured by Ajello *et al.* and James *et al.* (1990), except for  $v' = 1$  and 2, where  $A_{v'0}$  were too small to be measured, so  $A_{2v''}$  were normalized to the  $v' = 2$  radiative lifetime (0.65 ns) measured by Oertel *et al.* (1981), while  $A_{1v''}$  were normalized to the average of the radiative lifetimes for  $v' = 0$  (0.74 ns) deduced by Ajello *et al.* and  $v' = 2$  measured by Oertel *et al.* Bands from  $v' = 5$  are weak and their intensities have not been measured.

| $v' \setminus v''$ | 0                  | 1                 | 2                  | 3                  | 4                 | 5                 | 6                   | 7                 | 8                 |
|--------------------|--------------------|-------------------|--------------------|--------------------|-------------------|-------------------|---------------------|-------------------|-------------------|
| 0                  | 0.0959<br>1.14(9)* | 0.0980<br>1.88(8) | 0.1003<br>1.85(7)  | 0.1026<br>7.9(6)   | 0.1051<br>3.4(6)  | 0.1076<br>~1.5(6) | 0.1102<br><5.3(6)   | 0.1128<br><3.0(6) | 0.1156<br><2.9(6) |
| 1                  | 0.0940<br>2.9(7)   | 0.0961<br>~4.2(8) | 0.0983<br>~4.0(8)  | 0.1005<br>~6.0(7)  | 0.1029<br><6(7)   | 0.1053<br>~5(7)   | 0.1077<br>~3(8)     | 0.1103<br>~2.1(8) | 0.1130<br>~1.0(8) |
| 2                  | 0.0921<br>2.1(7)   | 0.0941<br>2.5(8)  | 0.0962<br>2.8(8)   | 0.0984<br>~9.3(7)  | 0.1006<br>~9.3(7) | 0.1029<br>~9(7)   | 0.1053<br>~1.3(8)   | 0.1077<br>~4.6(8) | 0.1102<br>~3.2(8) |
| 3                  | 0.0904<br>1.11(8)  | 0.0923<br>1.2(8)  | 0.0943<br>~5.7(8)  | 0.0964<br>6.1(8)   | 0.0985<br>3.4(8)  | 0.1007<br>4.7(7)† | 0.1030<br>~2(7)     | 0.1053<br>~3.9(7) | 0.1077<br>~5(7)   |
| 4                  | 0.0887<br>2.43(8)  | 0.0905<br>~1.5(8) | 0.0925<br>~9.7(6)  | 0.0945<br>~3.37(8) | 0.0965<br>~2.9(8) | 0.0986<br>~2.8(8) | 0.1008<br>~1.04(8)† | 0.1030<br>~1(7)   | 0.1053<br>~1(7)   |
| 6                  | 0.0856<br>1.63(8)  | 0.0874<br>2.0(8)  | 0.0891<br>~1.4(8)† | 0.0910<br>~2(7)†   | 0.0929<br>2.0(8)  | 0.0948<br>4.35(8) | 0.0968<br>~1.5(8)†  | 0.0989<br>2.84(8) | 0.1010<br>2.5(8)† |

\*Read as  $1.14 \times 10^9$ .

†Based on the upper limit value of the electron-impact emission cross section given in Table II of Ajello *et al.* (1989), less estimated contributions from overlapping features.

‡Based on a revised value of the electron-impact emission cross section,  $0.55 \times 10^{-19} \text{ cm}^2$  (Ajello, private communication, September 1990).

Table 38. Band head wavelengths and Einstein coefficients for N<sub>2</sub>  $c'_4 - 1\Sigma_u^+ - a - 1\Pi_g$ . For each  $v' - v''$  band, the listed quantities are  $\lambda_{Hv'v''}$  ( $\mu\text{m}$ ) and  $A_{v'v''}$  ( $\text{s}^{-1}$ ). Band heads from Lofthus and Krupenie (1977) (band origins not available). Einstein coefficients calculated from the electron-impact band intensities of Filippelli *et al.* (1984) relative to that of the  $c'_4 - X$  0-0 band of Ajello *et al.* (1989), normalized to the  $A_{00}(c'_4 - X)$  value of the latter.

| $v' \setminus v''$ | 0                  | 1                 | 2                 | 3                 | 4                 | 5                |
|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|------------------|
| 0                  | 0.2827<br>1.98(6)* | 0.2967<br>4.82(6) | 0.3119<br>3.40(6) | 0.3283<br>2.37(6) | 0.3463<br>1.37(6) | 0.3661<br>9.0(5) |

\*Read as  $1.98 \times 10^6$ .

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