

# Atlas of the Absorption Spectrum of Nitric Oxide (NO) between 1420 and 1250 Å

E. Miescher

*Institute of Physics, University of Basel, Klingelbergstrasse 82, 4056 Basel, Switzerland*

and

F. Alberti

*Herzberg Institute of Astrophysics, National Research Council of Canada, Ottawa K1A 0R6, Canada*

This atlas presents the absorption spectrum between 1420 and 1250 Å of cold ( $-180^{\circ}\text{C}$ ) nitric oxide gas, both  $^{14}\text{N}^{16}\text{O}$  and  $^{15}\text{N}^{16}\text{O}$ , photographed in first order of a 10.5 m vacuum spectrograph. The spectral region comprises the Rydberg series (*s*-, *p*-, *d*-, and *f*-) of the molecule, including their limits of  $v = 0, 1$ , and 2 of the ground state of the ion  $\text{NO}^+$ . In addition it shows some valence bands. To each band are assigned quantum numbers. The assignment is based on the detailed study of the fine structure of the bands, measured on spectral plates obtained in high order of the same instrument. Accurate numerical results of these measurements are tabulated for 140 molecular levels. A short survey on the NO absorption spectrum is given.

Key words: Absorption spectrum; identification atlas; nitric oxide; Rydberg series.

## 1. Introduction

The absorption spectrum of nitric oxide has been thoroughly studied during the last two decades and was recently reviewed in an article by Miescher and Huber [1]<sup>1</sup>. The present atlas reproduces part of it, namely the region between 1420 and 1250 Å, an interval which is singled out by the two following properties of the NO molecule. Near the long wavelength boundary, at 1395 Å, is the third dissociation limit  $\text{N}(^2\text{D}) + \text{O}(^3\text{P})$  of the molecule, and close to the short wavelength boundary, at 1260 Å, is the third ionization limit  $\text{NO}^+(X^1\Sigma^+, v=2) + e^-$ . The first ionization limit  $v=0$ , at 1338 Å, is located midway between. The region, therefore, comprises the limits of the Rydberg series converging to the three lowest vibrational levels of the ionic ground state, including the  $v=1$  series which has maximum intensity because of the magnitude of the Franck-Condon factors. Compared to the absorption spectrum in the near vacuum ultraviolet the structure of the bands in the spectral region of this atlas is much simpler because of the almost complete absence of non-Rydberg levels at energies exceeding the dissociation limit mentioned above. A photographic reproduction on a similar scale of the absorption spectrum between 1920 and 1400 Å has been published earlier [2].

## 2. Experimental

The spectra were photographed in 1965 at the 10.5 m

vacuum spectrograph of the National Research Council of Canada [3]. They were taken in the first order of a grating with 1200 lines/mm, reciprocal dispersion 0.75 Å/mm. The enlargement in figures 1–3 is sevenfold. The background is the Lyman continuum and shows some broadened Si lines, the O I triplet near 1305 Å and a few C I and Hg I lines. The NO gas, mixed with He, was contained in an absorption cell fitted with LiF windows. This cell, including the windows, was kept at the temperature of liquid oxygen. Spectra of ordinary  $^{14}\text{N}^{16}\text{O}$  and of high purity  $^{15}\text{N}^{16}\text{O}$  were photographed and are marked "14" and "15", respectively, in figures 1–3. Ilford Q II plates were used. The reproductions in figures 1–3 are made from the same original plates that had earlier served for a small scale reproduction of the spectra of four NO isotopes [4].

More recently, the whole spectral region of this atlas was photographed, both for  $^{14}\text{N}^{16}\text{O}$  and  $^{15}\text{N}^{16}\text{O}$ , in high order of the 10.5 m spectrograph by using a windowless cooled cell [5]. The wavenumber scale in figures 1–3 is accurately based on measurements made on these new plates which have low order iron reference lines.

## 3. Survey of the NO Absorption Spectrum

In this section a short discussion of the results of the analysis of the NO spectrum will be given. This is to clarify the assignments for the various bands in figures 1–3, and to make meaningful the remarks accompanying the accurate wavenumber given for each band in tables 1–3. The wavenumbers and the remarks originate from the study of the high resolution plates.

The low ionization potential of NO (9.25 eV) is responsible for the structure of the spectrum in the region of this atlas. The first Rydberg series in the spectrum of NO appears at much longer wavelengths than for  $\text{N}_2$

<sup>1</sup>Numbers in brackets indicate the literature references in section 6.

and O<sub>2</sub>. Nevertheless, its identification came late, in spite of the fact that already the lowest excited doublet state,  $A' \ ^2\Sigma^+$ , is characterized by rotational and vibrational constants equal to the constants of the ionic state, and thus certainly is a Rydberg state.

The ground state of NO is a "case a"  $^2\Pi$  state with  $A=+124 \text{ cm}^{-1}$ . This doublet splitting appears in all absorption bands. In the cooled gas the  $^2\Pi_{3/2}$  level is only little populated, and the  $X \ ^2\Pi_{3/2}$  sub-bands are therefore weak, thus easing troublesome overlapping. Excited states of  $^2\Sigma$ ,  $^2\Pi$ , and  $^2\Delta$  symmetry can combine with the  $^2\Pi$  ground state.  $\Lambda$  is a good quantum number for the valence (NR) states. For Rydberg (R) states, however, in which the Rydberg electron is in a  $d$  or  $f$  atomic orbital and gives rise to  $d$  and  $f$  term complexes, "case d" is approached in the rotating molecule and  $\Lambda$  is lost. Due to the  $d$ -like shape of the  $2\pi^*$  orbital of the 15th electron in the ground state configuration of NO the  $nd\sigma-X$  and  $nd\pi-X$  Rydberg series are very weak in absorption and are not observed above  $n=4$ . Only  $nd\delta-X$  Rydberg series appear to higher  $n$  in the spectrum in consequence of the peculiar structure of the  $d$  complexes [6]. The  $nf-X$  Rydberg series are the prominent features exhibiting sharp rotational lines.

Whereas strong interactions between Rydberg and valence (NR) states produce extensive perturbations of different kinds in the near vacuum ultraviolet part of the spectrum, such perturbations are much less abundant in the spectral region of figures 1-3.  $^2\Pi$  NR levels mixed with  $^2\Pi$  R levels [7] occur only in the bands  $c-X$ ,  $d-X$  and  $e-X$  which converge to the dissociation limit at  $1395 \text{ \AA}$ . Another NR progression is formed by the  $G \ ^2\Sigma^-X \ ^2\Pi$  bands, overshooting this limit with the (10, 0) and (11, 0) bands and abruptly terminating with the (12, 0) band. The three bands show broadened rotational lines. The  $I \ ^2\Sigma^+X \ ^2\Pi$  (7, 0) band [7] at  $1409 \text{ \AA}$  is a red degraded diffuse NR band in the  $^{14}\text{N}^{16}\text{O}$  spectrum. It appears as a symmetric absorption maximum in the  $^{15}\text{N}^{16}\text{O}$  spectrum, where its position coincides with the calculated position of the missing  $6p\sigma-X$  (0, 0) R band.  $^2\Delta$  NR levels, finally, cannot be located accurately, but in figure 1 the existence of at least one such level near  $72\,540 \text{ cm}^{-1}$  is indicated by the perturbed structures of the  $5d\delta-X$  (1, 0) bands in the two isotope spectra.

The first dissociation limit of NO is known to be at  $52\,400 \text{ cm}^{-1}$  ( $1908 \text{ \AA}$ ), at a far longer wavelength outside figure 1. The much discussed [1] continuous state  $A' \ ^2\Sigma^+$ , arising from the unexcited atoms, produces weak predissociation (absence of emissions) of the sharp  $^2\Pi$  NR levels and, as a consequence of the mixing, also predissociation of the  $^2\Pi$  R levels. Furthermore, it is responsible for many broadenings observed in  $^2\Sigma^+$  NR and R levels. The  $A' \ ^2\Sigma^+$  potential curve merges into the potential curves of the Rydberg states around  $68\,000 \text{ cm}^{-1}$ . Above this energy it produces the strong mixing effects referred to in column (6) of the tables.

The lettering of figures 1-3 separates bands having sharp rotational lines from bands with diffuse fine structure. All  $ns-X$  and all  $nf-X$  Rydberg bands are sharp, whereas most of the  $np-X$  bands and many  $nd\delta-X$  bands are diffuse. Details are given in the tables.

Photoionization spectrometric measurements in the region of this atlas have recently been published [8], [9]. The stepwise curve, first observed by Watanabe [10], clearly reflects the vibrational structure of the  $\text{NO}^+$  ground state, the observed fine structure, however, has only tentatively been interpreted up to now.

#### 4. Conclusion

The shortest wavelength in the spectrum of this atlas is  $1250 \text{ \AA}$ . The spectrum of NO below  $1250 \text{ \AA}$  has been observed by Watanabe, Matsunaga, and Sakai [11] with moderate resolution and on a discontinuous background. They found a pronounced, probably diffuse band structure starting below  $1110 \text{ \AA}$  for which an interpretation is still lacking.

Bands with sharp and with diffuse fine structure have been segregated from each other in the labelling of the figures of this atlas, because only diffuse levels are of interest in connection with the questions of preionization and predissociation. Fano shapes of such bands are not seen in the region of this atlas. Most probably electronic interaction with repulsive valence states, which must exist, leads to dissociation of the molecular core in the case of the diffuse  $np$  Rydberg levels.  $\Delta v=1$  vibrational interaction between two Rydberg levels, of the kind observed for H<sub>2</sub> by Herzberg and Jungen [12], are conceivable in the cases of the overlapping  $9p(v)$  and  $6p(v+1)$  bands ( $v=0, 1, \text{ and } 2$ ).  $\Delta v=2$  interaction is possible in the cases of the near-coinciding  $10p\sigma(v)$  and  $5p\sigma(v+2)$  bands ( $v=1 \text{ and } 2$ ). These observations and, in addition, rotational interaction observed between Rydberg bands with sharp structures will be discussed in a future paper.

#### 5. Acknowledgments

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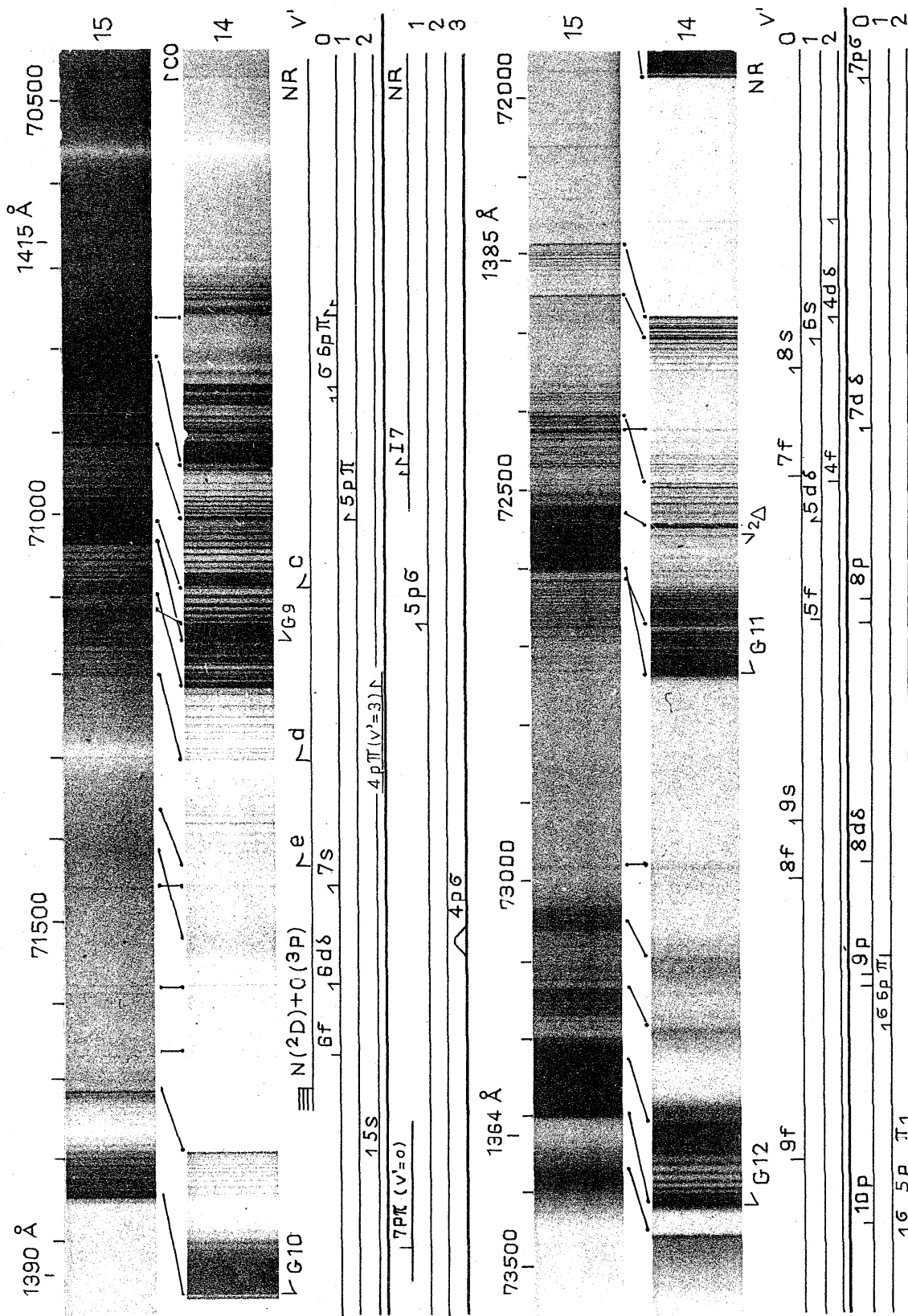


FIGURE 1. Absorption spectrum 1360–1419  $\text{\AA}$  of cold ( $-180\text{ }^\circ\text{C}$ ) nitric oxide  $^{14}\text{N}^{16}\text{O}$  and  $^{15}\text{N}^{16}\text{O}$  (marked "14" and "15", respectively, on the right side of the spectra). At the top of the spectrum is the scale in wavenumbers ( $\text{cm}^{-1}$ ), at the bottom is the assignment of the bands of the "14" spectrum. Isotope shifts are marked in the space between the two isotope spectra. Notation: NR = valence band, e.g.:  $G9 = G^2\Sigma^-X^2\Pi_{1/2}(9, 0)$  band. Rydberg bands or  $n$ -complexes,  $n\Lambda-X^2\Pi_{1/2}(v', 0)$  bands, are lettered " $n\Lambda$ " on separate lines corresponding to the Rydberg series converging to the limits  $v' = 0, 1, 2, \dots$  of the ionic ground state. ( $n$  = principal quantum number,  $l = s, p, \dots$  = orbital quantum number of the Rydberg electron,  $\lambda = \sigma, \pi, \dots$  = component of  $l$  along the molecular axis). Quantum symbols above and below the heavy line refer to bands with sharp and diffuse rotational structure, respectively.

TABLE 1. <sup>14</sup>N<sup>16</sup>O, 1360–1419 Å. Accurate wavenumbers and notes to the assignment of the bands lettered on figure 1.

(1) Wavenumber <sup>a</sup> cm <sup>-1</sup>	(2) Branch <sup>b</sup>	(3) ( <sup>c</sup> )	(4) State	(5) Band	(6) Remarks	(7) References <sup>d</sup>
70 741.5	<i>P</i> <sub>11</sub> (1½)		} <i>W</i> <sup>2</sup> Π	<i>6pπ</i> - <i>X</i> (0, 0)	Mixed with NR levels	[4], [7]
70 759.5	<i>R</i> <sub>11</sub> (5½)	h				
70 827.6	<i>P</i> <sub>11</sub> (7½)	h	} <i>Y</i> <sup>2</sup> Σ <sup>+</sup>	<i>6pσ</i> - <i>X</i> (0, 0)	Mixed with <i>I</i> <sup>2</sup> Σ <sup>+</sup> ( <i>v</i> =7) in <sup>15</sup> N <sup>16</sup> O	[4], [7]
70 845.5	<i>Q</i> <sub>11</sub> (1½)	h				
70 939	<i>R</i>	h	} NR	<i>I</i> <sup>2</sup> Σ <sup>+</sup> - <i>X</i> (7, 0)	Very diff., interact. with <i>A'</i> <sup>2</sup> Σ <sup>+</sup> ; <i>v'</i> =7?	[7]
70 951	<i>Q</i>	h				
71 009.0	<i>R</i> <sub>11</sub> (2½)	h	<i>Q</i> <sup>2</sup> Π	<i>5pπ</i> - <i>X</i> (1, 0)	Mixed with NR levels	[7]
71 089.8	<i>R</i> <sub>11</sub> (1½)	h	NR	<i>c</i> <sup>2</sup> Π- <i>X</i> (-, 0)	Mixed with R levels	[7]
71 138		h	<i>R</i> <sup>2</sup> Σ <sup>+</sup>	<i>5pσ</i> - <i>X</i> (1, 0)	Very diff. overl.	
71 160.0	<i>R</i> <sub>21</sub> (1½)	h	NR	<i>G</i> <sup>2</sup> Σ <sup>-</sup> - <i>X</i> (9, 0)		[11]
71 215.6	<i>R</i> <sub>11</sub> (1½)	h	<i>K</i> <sup>2</sup> Π	<i>4pπ</i> - <i>X</i> (3, 0)	Mixed with NR levels	[7], [14]
71 305.6	<i>R</i> <sub>11</sub> (½)	h	NR	<i>d</i> <sup>2</sup> Π- <i>X</i> (-, 0)	Mixed with R levels	[7]
71 433.7	<i>R</i> <sub>11</sub> (½)	h	NR	<i>e</i> <sup>2</sup> Π- <i>X</i> (-, 0)	Mixed with R levels	[7]
71 457.6	<i>Q</i> <sub>11</sub> (3½)	h	<i>Z</i> <sup>2</sup> Σ <sup>+</sup>	<i>7sσ</i> - <i>X</i> (0, 0)		[4]
71 528		m	<i>M</i> <sup>2</sup> Σ <sup>+</sup>	<i>4pσ</i> - <i>X</i> (3, 0)	30 cm <sup>-1</sup>	
71 582.4	<i>Q</i> <sub>11</sub> (3½)	h	<sup>2</sup> Δ	<i>6dδ</i> - <i>X</i> (0, 0)		[4]
71 662.6	<sup>-1/2</sup> <i>R</i> <sub>+2</sub> (3½)	h		<i>6f</i> - <i>X</i> (0, 0)		[4]
71 790.3	<i>Q</i> <sub>11</sub> (3½)	h	<i>S</i> <sup>2</sup> Σ <sup>+</sup>	<i>5sσ</i> - <i>X</i> (2, 0)		[14]
(71 910)			<sup>2</sup> Π	<i>7pπ</i> - <i>X</i> (0, 0)	Very diff., overl.	
71 974	<i>R</i> <sub>21</sub> (1½)	h	NR	<i>G</i> <sup>2</sup> Σ <sup>-</sup> - <i>X</i> (10, 0)	Diff. 0.2 cm <sup>-1</sup>	[13]
71 985	<i>Q</i> <sub>11</sub> (2½)	h	<sup>2</sup> Σ <sup>+</sup>	<i>7pσ</i> - <i>X</i> (0, 0)	Diff. 1 cm <sup>-1</sup>	
72 155.1	<i>Q</i> <sub>12</sub> (4½)	h	} <i>N</i> <sup>2</sup> Δ	<i>4dδ</i> - <i>X</i> (2, 0)		[15]
72 275.9	<i>Q</i> <sub>11</sub> (4½)	h				
72 301.4	<i>Q</i> <sub>11</sub> (4½)	h	<i>T</i> <sup>2</sup> Σ <sup>+</sup>	<i>6sσ</i> - <i>X</i> (1, 0)		[4]
72 347.4	<i>Q</i> <sub>11</sub> (3½)	h	<sup>2</sup> Σ <sup>+</sup>	<i>8sσ</i> - <i>X</i> (0, 0)		
72 418.1	<i>Q</i> <sub>11</sub> (4½)	h	<sup>2</sup> Δ	<i>9dδ</i> - <i>X</i> (0, 0)	Diff. 0.2 cm <sup>-1</sup>	
72 474.5	<sup>-1/2</sup> <i>R</i> <sub>+2</sub> (3½)	h		<i>7f</i> - <i>X</i> (0, 0)	Overl.	
72 487.4	<sup>-1/2</sup> <i>R</i> <sub>+2</sub> (3½)	h		<i>4f</i> - <i>X</i> (2, 0)		[4]
72 544.4	<i>Q</i> <sub>21</sub> (5½)	h	<i>U</i> <sup>2</sup> Δ	<i>5dδ</i> - <i>X</i> (1, 0)	Perturbed by NR level	[4]
72 552.8	<i>Q</i> <sub>11</sub> (7½)		NR	<sup>2</sup> Δ - <i>X</i> (-, 0)	Perturbed by R level	
(72 632)			<sup>2</sup> Π	<i>8pπ</i> - <i>X</i> (0, 0)	Very diff. overl.	
72 660.2	<sup>-1/2</sup> <i>R</i> <sub>+2</sub> (3½)	h		<i>5f</i> - <i>X</i> (1, 0)		
(72 678)			<sup>2</sup> Σ <sup>+</sup>	<i>8pσ</i> - <i>X</i> (0, 0)	Very diff., overl.	
72 729	<i>R</i> <sub>21</sub>	h	NR	<i>G</i> <sup>2</sup> Σ <sup>-</sup> - <i>X</i> (11, 0)	Diff. 2 cm <sup>-1</sup>	
72 916.9	<i>Q</i> <sub>11</sub> (4½)	h	<sup>2</sup> Σ <sup>+</sup>	<i>9sσ</i> - <i>X</i> (0, 0)		
72 971.5	<i>Q</i> <sub>21</sub> (1½)		<sup>2</sup> Δ	<i>8dδ</i> - <i>X</i> (0, 0)	Diff. 1 cm <sup>-1</sup>	
73 001.4	<sup>-1/2</sup> <i>R</i> <sub>+2</sub> (3½)	h		<i>8f</i> - <i>X</i> (0, 0)		
73 096			<i>W</i> <sup>2</sup> Π	<i>6pπ</i> - <i>X</i> (1, 0)	Very diff. 6 cm <sup>-1</sup>	
(73 108)			<sup>2</sup> Π	<i>9pπ</i> - <i>X</i> (0, 0)	Very diff. overl.	
73 143	<i>Q</i> <sub>11</sub> (1½)	h	<sup>2</sup> Σ <sup>+</sup>	<i>9pσ</i> - <i>X</i> (0, 0)	Diff. 3 cm <sup>-1</sup>	
73 188	<i>Q</i> <sub>11</sub> (2½)	h	<i>Y</i> <sup>2</sup> Σ <sup>+</sup>	<i>6pσ</i> - <i>X</i> (1, 0)	Diff. 3 cm <sup>-1</sup>	
(73 306)			<sup>2</sup> Σ <sup>+</sup>	<i>10sσ</i> - <i>X</i> (0, 0)	Overl.	
73 313			<i>Q</i> <sup>2</sup> Π	<i>5pπ</i> - <i>X</i> (2, 0)	Very diff. 8 cm <sup>-1</sup>	
73 362.7	<sup>-1/2</sup> <i>R</i> <sub>+2</sub> (3½)	h		<i>9f</i> - <i>X</i> (0, 0)	Overl.	
73 423	<i>R</i> <sub>21</sub> (1½)	h	NR	<i>G</i> <sup>2</sup> Σ <sup>-</sup> - <i>X</i> (12, 0)	Diff. 2 cm <sup>-1</sup>	
(73 440)				<i>10p</i> - <i>X</i> (0, 0)		
73 459.5	<i>Q</i> <sub>11</sub> (2½)	h	<i>R</i> <sup>2</sup> Σ <sup>-</sup>	<i>5pσ</i> - <i>X</i> (2, 0)	Diff. 1 cm <sup>-1</sup>	

<sup>a</sup> Measured band position in cm<sup>-1</sup>. Calculated positions in parentheses.

<sup>b</sup> Identification of the branch or rotational line referred to in column (1). If overlapping lines form a head, the line of lowest *J''* is given. *nf-X* bands: <sup>-1/2</sup>*R*<sub>+2</sub> is the conspicuous head of the *R*-branch for which *R'-J''* = -½ and *ℓ* = +2. *R'* = rotational quantum number of the core, *ℓ* = component of *l* = 3 of the Rydberg electron along the rotational axis (see ref. [16]).

<sup>c</sup> h = head, m = maximum of symmetrical continuum.

<sup>d</sup> Bands for which no reference is given are reported here for the first time. All wavenumbers in column (1) originate from measurements made on the new high order plates mentioned in section 2.

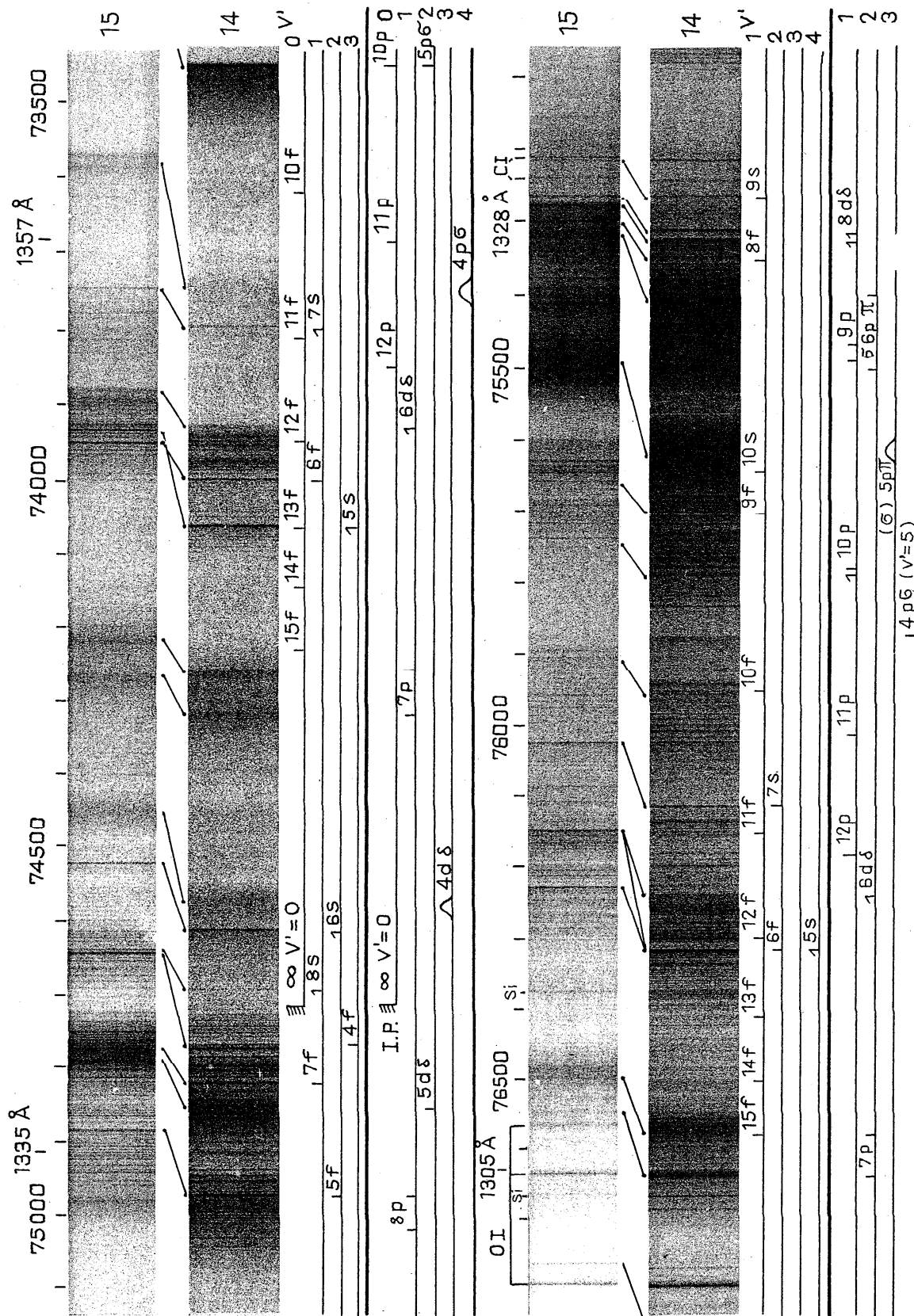


FIGURE 2. Absorption spectrum 1302-1360 Å. See caption to figure 1.

TABLE 2. <sup>14</sup>N<sup>16</sup>O, 1302–1360 Å. Accurate wavenumbers and notes to the assignment of the bands lettered on figure 2.

[For footnotes, see table 1.]

(1) Wavenumber <sup>a</sup> cm <sup>-1</sup>	(2) Branch <sup>b</sup>	(3) ( <sup>c</sup> )	(4) State	(5) Band	(6) Remarks	(7) References <sup>d</sup>
73 581.0	Q <sub>11</sub> (1½)		<sup>2</sup> Σ <sup>+</sup>	11sσ -X (0, 0)		
73 620.8	-1/2R <sub>+2</sub> (3½)	h		10f -X (0, 0)		
(73 684)				11p -X (0, 0)		
73 750		m	M <sup>2</sup> Σ <sup>+</sup>	4pσ -X (4, 0)	30 cm <sup>-1</sup>	
73 801.8	Q <sub>11</sub> (3½)	h	Z <sup>2</sup> Σ <sup>+</sup>	7sσ -X (1, 0)		[4]
73 812.0	-1/2R <sub>+2</sub> (3½)	h		11f -X (0, 0)		
(73 858)				12p -X (0, 0)		
73 933	Q <sub>11</sub> (3½)	h	<sup>2</sup> Δ	6dδ -X (1, 0)	Diff. 1 cm <sup>-1</sup>	[4]
(73 956)	-1/2R <sub>+2</sub> (3½)	h		12f -X (0, 0)	Overl.	
74 006.0	-1/2R <sub>+2</sub> (3½)	h		6f -X (1, 0)		
74 069.0	Q <sub>11</sub> (3½)	h	S <sup>2</sup> Σ <sup>+</sup>	5sσ -X (3, 0)		
74 070.0	-1/2R <sub>+2</sub> (3½)	h		13f -X (0, 0)	Overl.	
74 159.3	-1/2R <sub>+2</sub> (3½)	h		14f -X (0, 0)		
74 231.5	-1/2R <sub>+2</sub> (3½)	h		15f -X (0, 0)		
74 268	Q <sub>11</sub> (2½)	h	<sup>2</sup> Π	7pπ -X (1, 0)	Diff. 2 cm <sup>-1</sup>	
74 332	Q <sub>11</sub> (2½)	h	<sup>2</sup> Σ <sup>+</sup>	7pσ -X (1, 0)	Diff. 2 cm <sup>-1</sup>	
74 579		m	N <sup>2</sup> Δ	4dδ -X (3, 0)	20 cm <sup>-1</sup>	
74 612.0	Q <sub>11</sub> (2½)	h	T <sup>2</sup> Σ <sup>+</sup>	6sσ -X (2, 0)		[4]
74 691.1	Q <sub>11</sub> (3½)	h	<sup>2</sup> Σ <sup>+</sup>	8sσ -X (1, 0)		
74 765.7	-1/2R <sub>+2</sub> (3½)	h		4f -X (3, 0)		[4]
74 818.8	-1/2R <sub>+2</sub> (3½)	h		7f -X (1, 0)		
74 860		m	U <sup>2</sup> Δ	5dδ -X (2, 0)	Overl.	[4]
74 970.8	-1/2R <sub>+2</sub> (3½)	h		5f -X (2, 0)		[4]
(74 973)			<sup>2</sup> Π	8pπ -X (1, 0)	Very diff., overl.	
(75 018)			<sup>2</sup> Σ <sup>+</sup>	8pσ -X (1, 0)	Very diff., overl.	
75 260.6	Q <sub>11</sub> (5½)	h	<sup>2</sup> Σ <sup>+</sup>	9sσ -X (1, 0)		
75 309.5	Q <sub>11</sub> (3½)		<sup>2</sup> Δ	8dδ -X (1, 0)	Diff. 1 cm <sup>-1</sup>	
75 322	R <sub>11</sub> (2½)	h				
75 345.4	-1/2R <sub>+2</sub> (3½)	h		8f -X (1, 0)		
75 400			W <sup>2</sup> Π	6pπ -X (2, 0)	Very diff.	
75 460	Q <sub>11</sub>		<sup>2</sup> Π	9pπ -X (1, 0)	Diff. 2 cm <sup>-1</sup>	
75 490	Q <sub>11</sub> (1½)	h	<sup>2</sup> Σ <sup>+</sup>	9pσ -X (1, 0)	Diff. 2 cm <sup>-1</sup>	
(75 502)			Y <sup>2</sup> Σ <sup>+</sup>	6pσ -X (2, 0)	Diff., overl.	
75 620		m	Q <sup>2</sup> Π	5pπ -X (3, 0)	50 cm <sup>-1</sup>	
75 656.9	R <sub>11</sub> (1½)		<sup>2</sup> Σ <sup>+</sup>	10sσ -X (1, 0)		
75 706.2	-1/2R <sub>+2</sub> (2½)	h		9f -X (1, 0)		
			R <sup>2</sup> Σ <sup>+</sup>	5pσ -X (3, 0)	Absent, interact. with A' <sup>2</sup> Σ <sup>+</sup>	
(75 777)			<sup>2</sup> Π	10pπ -X (1, 0)	Diff. 4 cm <sup>-1</sup>	
75 803	Q <sub>11</sub> (1½)		<sup>2</sup> Σ <sup>+</sup>	10pσ -X (1, 0)	Diff. 2 cm <sup>-1</sup>	
75 872		h	M <sup>2</sup> Σ <sup>+</sup>	4pσ -X (5, 0)	Diff. 2 cm <sup>-1</sup>	
75 931.9	R <sub>11</sub> (1½)		<sup>2</sup> Σ <sup>+</sup>	11sσ -X (1, 0)		
75 964.6	-1/2R <sub>+2</sub> (2½)	h		10f -X (1, 0)		
(76 024)				11p -X (1, 0)	Diff.	
76 112.6	Q <sub>11</sub> (3½)	h	Z <sup>2</sup> Σ <sup>+</sup>	7sσ -X (2, 0)		[4]
76 156.4	-1/2R <sub>+2</sub> (2½)	h		11f -X (1, 0)		
(76 200)				12p -X (2, 0)	Diff.	
76 238		h	<sup>2</sup> Δ	6dδ -X (2, 0)	Very diff.	
76 301.0	-1/2R <sub>+2</sub> (2½)	h		12f -X (1, 0)		
76 316.0	Q <sub>11</sub>	h	S <sup>2</sup> Σ <sup>+</sup>	5sσ -X (4, 0)	Overl.	
76 317.3	-1/2R <sub>+2</sub> (3½)	h		6f -X (2, 0)	Overl.	[4]
76 413.8	-1/2R <sub>+2</sub>	h		13f -X (1, 0)		
76 503.0	-1/2R <sub>+2</sub>	h		14f -X (1, 0)		
76 575	-1/2R <sub>+2</sub>	h		15f -X (1, 0)		
(76 600)				7p -X (2, 0)	Diff. masked by O I lines	

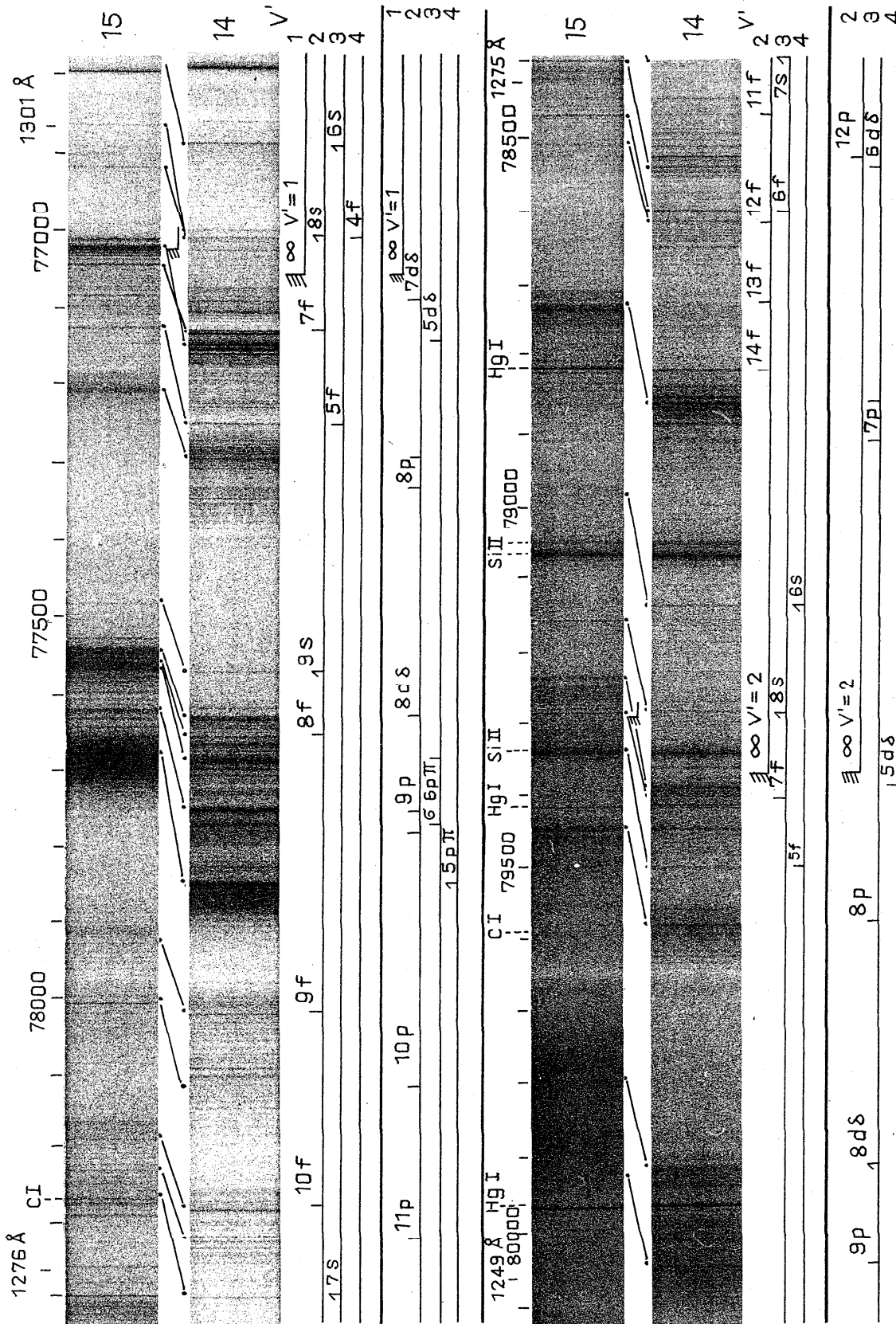


FIGURE 3. Absorption spectrum 1249-1302 Å. See caption to figure 1.



TABLE 3. <sup>14</sup>N<sup>16</sup>O, 1249-1302 Å. Accurate wavenumbers and notes to the assignment of the bands lettered on figure 3.

[For footnotes, see table 1.]

(1) Wavenumber <sup>a</sup> cm <sup>-1</sup>	(2) Branch <sup>b</sup>	(3) ( <sup>c</sup> )	(4) State	(5) Band	(6) Remarks	(7) References <sup>d</sup>
76 889.8	Q <sub>11</sub> (3½)	h	T <sup>2</sup> Σ <sup>+</sup>	6sσ -X (3, 0)		
77 002.0	Q <sub>11</sub> (4½)	h	<sup>2</sup> Σ <sup>+</sup>	8sσ -X (2, 0)		
77 011.3	-1/2R <sub>+2</sub> (3½)	h		4f -X (4, 0)		
(77 085)			<sup>2</sup> Δ	7dδ -X (2, 0)		
77 129.6	-1/2R <sub>+2</sub> (3½)	h		7f -X (2, 0)		
77 134		m	U <sup>2</sup> Δ	5dδ -X (3, 0)	Diff., perturbed	[4]
77 248.5	-1/2R <sub>+2</sub> (3½)	h		5f -X (3, 0)		
77 290		m	<sup>2</sup> Π	8pπ -X (2, 0)	Very diff.	
77 332		h	<sup>2</sup> Σ <sup>+</sup>	8pσ -X (2, 0)	Diff. 1 cm <sup>-1</sup>	
77 571.7	Q <sub>11</sub> (4½)	h	<sup>2</sup> Σ <sup>+</sup>	9sσ -X (2, 0)		
77 626		h	<sup>2</sup> Δ	8dδ -X (2, 0)	Very diff.	
77 656.6	-1/2R <sub>+2</sub> (3½)	h		8f -X (2, 0)		
77 690		m	W <sup>2</sup> Π	6pπ -X (3, 0)	8 cm <sup>-1</sup>	
77 752		m	<sup>2</sup> Π	9pπ -X (2, 0)	2 cm <sup>-1</sup>	
77 778			Y <sup>2</sup> Σ <sup>+</sup>	6pσ -X (3, 0)	Very diff., overl.	
77 796	Q <sub>11</sub> (2½)		<sup>2</sup> Σ <sup>+</sup>	9pσ -X (2, 0)	Diff. 3 cm <sup>-1</sup>	
77 850	Q <sub>11</sub> (4½)	h	Q <sup>2</sup> Π	5pπ -X (4, 0)	Diff. 1 cm <sup>-1</sup>	
			R <sup>2</sup> Σ <sup>+</sup>	5pσ -X (4, 0)	Absent, interact. with A' <sup>2</sup> Σ <sup>+</sup> and 10pσ (ν=2)	
77 961.5	Q <sub>11</sub> (1½)		<sup>2</sup> Σ <sup>+</sup>	10sσ -X (2, 0)		
78 017.8	-1/2R <sub>+2</sub> (3½)	h		9f -X (2, 0)		
(78 090)			<sup>2</sup> Π	10pπ -X (2, 0)		
78 118.3	Q <sub>11</sub> (½)		<sup>2</sup> Σ <sup>+</sup>	10pσ -X (2, 0)	Diff. 0.5 cm <sup>-1</sup>	
78 237.4	Q <sub>11</sub> (½)		<sup>2</sup> Σ <sup>+</sup>	11sσ -X (2, 0)		
78 275.8	-1/2R <sub>+2</sub> (3½)	h		10f -X (2, 0)		
(78 330)				11p -X (2, 0)	Diff., overl.	
78 391.2	Q <sub>11</sub> (3½)	h	Z <sup>2</sup> Σ <sup>+</sup>	7sσ -X (3, 0)		
78 466.9	-1/2R <sub>+2</sub> (3½)	h		11f -X (2, 0)		
(78 510)				12p -X (2, 0)		
(78 530)			<sup>2</sup> Δ	6dδ -X (3, 0)		
78 595.8	-1/2R <sub>+2</sub> (3½)	h		6f -X (3, 0)		
78 611.4	-1/2R <sub>+2</sub> (3½)	h		12f -X (2, 0)		
78 725.2	-1/2R <sub>+2</sub> (3½)	h		13f -X (2, 0)		
78 814.3	-1/2R <sub>+2</sub> (3½)	h		14f -X (2, 0)		
78 850			<sup>2</sup> Π	7pπ -X (3, 0)	Very diff.	
(78 910)			<sup>2</sup> Σ <sup>+</sup>	7pσ -X (3, 0)	Very diff.	
79 134.2	Q <sub>11</sub> (2½)	h	T <sup>2</sup> Σ <sup>+</sup>	6sσ -X (4, 0)		
79 280.6	Q <sub>11</sub> (2½)	h	<sup>2</sup> Σ <sup>+</sup>	8sσ -X (3, 0)		
79 385			<sup>2</sup> Δ	5dδ -X (4, 0)	Diff., overl.	
79 408.6	-1/2R <sub>+2</sub> (3½)	h		7f -X (3, 0)		
79 495	-1/2R <sub>+2</sub>	h		5f -X (4, 0)		
79 580				8p -X (3, 0)	Very diff.	
(79 910)			<sup>2</sup> Δ	8dδ -X (3, 0)	} Not measurable on high resolution plate	
(80 050)				9p -X (3, 0)		