WAVELENGTHS OF ELECTRONIC TRANSITIONS

IN FOIL-EXCITED BEAMS

OF LIGHT ELEMENTS

by

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Sept. 10, 1965
Date

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N66-16702

ABSTRACT

Resolved spectral lines from deuterium, carbon, nitrogen and oxygen were recorded on photographic plates in experiments conducted by Bashkin, Malmberg, Meinel, and Tilford [1]. In each case, the source of the light was a beam of particles which, following acceleration in a Van de Graaff generator, passed through a thin carbon foil. Comparison spectra, from a standard iron-neon lamp, were also recorded on each plate.

We have used the plates provided by the above persons in order to

a) measure the wavelengths of the spectral lines characteristic of the radiating beams, and

b) identify the transitions responsible for those lines.

We have measured the wavelengths of 109 spectral lines, identified the transitions responsible for 26, and specified possible transitions for 54 others.

Author

INTRODUCTION

Spectroscopy has long been a major method of probing atomic parameters, and although the analyzing machines have come a long way since Fraunhofer's time, the methods of creating spectra have not been basically changed. These methods, flames, sparks, arcs, discharge tubes, hollow cathodes, and shock tubes, are based simply on heating a gas to incandescence. While these methods work very well and can create spectral lines measurable to 0.0001 Å, they do have several drawbacks. The first is the limited number of spectral lines which they can create. While a high voltage spark may occasionally create a fairly high charge state, it does not do so with a very high efficiency; and since it does create a mixture of charge states, deciding which line belongs to which charge state is a further problem. There is the problem of sample purity. Slight impurities may be present in the sample or some may be introduced from the walls or electrodes in the source chamber. Finally, there are other interesting atomic parameters besides the energies of atomic levels, particularly transition probabilities. These excitation methods do not lend themselves to a simple method of measuring these probabilities or of the lifetimes of the excited states.

This was the state of the art before December 1963 when Bashkin and Meinel [2] used a Van de Graaff accelerator provided by High Voltage Engineering Corporation to create spectra by a new method—one originally proposed by Bashkin in 1961 [3]. The Van de Graaff accelerator was used as a source for a beam of ions in a 10^{-5} torr vacuum. The beam was passed through a magnetic field to separate out the desired charge to mass ratio, and this desired segment was then directed through a 10 $\mu gm/cm^2$-thick carbon foil. While in the foil, the ions were excited into various electronic states and these states began to decay as the particles left the foil. The light emitted by the beam was focussed onto a grating spectrograph slit and photographic plates were taken of the resulting spectra. This method of excitation does overcome some of the disadvantages of the more conventional methods. First, high charge states may be examined. The incident beam consists of +1 or +2 states, but after passing through the foil, practically the complete range of possible charge states may be obtained, with the relative amounts of the different charge states depending upon the energy of the incident beam. This mixture of charge states may be left unresolved as in thermal sources, or a transverse electric field may be used to split the emergent beam into several beams of different parabolic paths—each with a different charge state. Such an electric field was not used in the experiment under discussion, but one has been used successfully by Bashkin, Malmberg, and Tilford [4].

As for sample purity, the magnetic field eliminates all contaminants, including isotopic contaminants, except those which have the same charge to mass ratio as the selected beam. Because an impurity with the same charge to mass ratio as the sample is a remote possibility, the beam incident on the foil is essentially of a single charge state and a single mass at a well defined energy and velocity. Since all the particles are moving with the same velocity, the distance a group of particles is from the foil is directly proportional to the time elapsed since their excitation. As the beam travels away from the foil, the populations of the excited states decrease and the intensity of the radiated light also decreases. This decrease of intensity with distance provides a direct measurement of the lifetimes of the excited states.

An additional feature of this excitation method is that since it is not a method of thermal excitation, it may be able to populate heretofore inattainable energy levels and thus give rise to previously unseen spectral lines.

After the original work at High Voltage Engineering showed that this method is practical, Bashkin, Malmberg, Meinel, and Tilford [1] used a Van de Graaff accelerator provided by the Naval Research Laboratory at Washington, D. C. to do a more comprehensive series of experiments in January 1964. This thesis is the wavelength analysis of the spectral plates taken by Bashkin *et al.* at NRL in January 1964.

EXPERIMENT AND ANALYSIS

The experiment performed at NRL was basically the same as that done at High Voltage Engineering. The first order spectra were recorded with an all-quartz system at a dispersion of about 140 Å/mm. Comparison spectra of neon and iron were then added to the plates. A mixture of D_2, He, N_2, and CO_2 was used as a source for the beam, and accelerating potentials ranged from 0.9 MV to 4 MV.

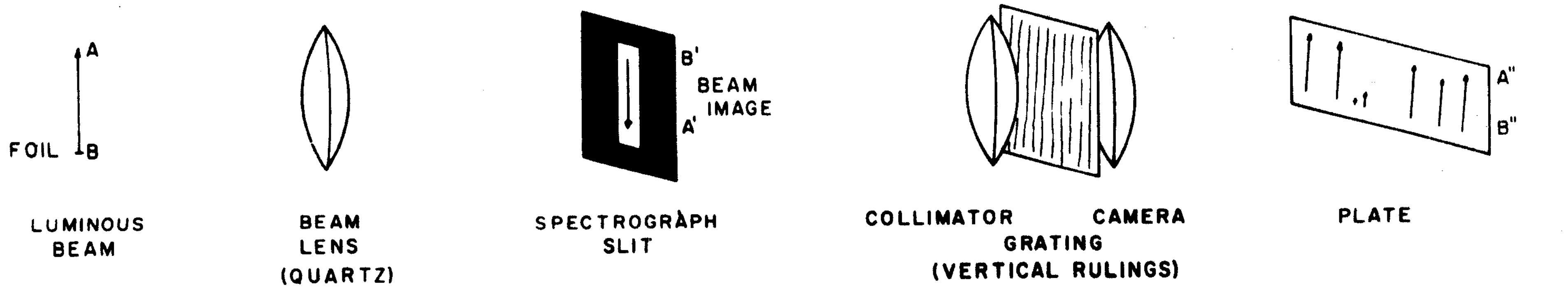
Distances between spectral lines on the plates were measured with a traveling microscope. At first the plates were read several times using different parts of the microscope's micrometer screw and turning the plates end for end. Distances were usually reproducible to 4 microns, and quite often to 1 micron. At the dispersion of these plates, 4 microns corresponds to less than 0.6 Å of wavelength. The plates used for the original identification of the comparison spectrum were read from two to seven times, the other plates were read one or two times.

Deuterium was one of the sample gases, and since it has a readily identifiable spectrum, the deuterium plates were used to make the first identification of the neon and iron comparison spectra. Wavelengths of neon near D_α were obtained from the <u>Handbook of Chemistry and Physics</u> [5] and fitted to the plate. The dispersion between these lines was then checked against the dispersion between D_α: D_β, and D_γ. From this point, the procedure was to: (1) calculate the dispersion between two lines, (2) measure the distance to the next line, (3) calculate the wavelength of this next line, (4) find the closest bright line in the table. An error in identification was revealed when identification of the next line on the plate proved unsuccessful. Identification of the neon spectrum was not too difficult because, in the region between D_α and D_β, neon has a number of very bright, fairly evenly spaced lines, all of which showed up on the plates, and a number of very dim lines, none of which showed up on the plates.

The procedure used on the neon was continued for the iron, but the iron spectrum proved to be much more difficult to identify. Contributing problems were the poor quality of the photographic image and the low dispersion and resolution of the spectrograph.

After identifying the comparison spectrum as well as possible, a curve was drawn of dispersion vs. distance along the plate. One line was chosen as a zero point; the distance from the zero point to each other line, the wavelength difference, and then the dispersion were calculated. For any line that was far off the curve, the tables were consulted to see if a better identification could be made. This curve was then used to find the wavelengths of the unknown lines. The dispersion at each unknown line's position was interpolated from the graph and multiplied by the line's distance from the zero point to obtain the wavelength difference.

Upon examining the plates, the spectral lines of the sample were seen to be slanted, slightly triangular, of various intensities, and of decreasing intensities along their lengths. All of these characteristics except the intensities ware caused by the optical arrangement that was used. The optical arrangement of the experiment, as shown in Fig. 1, had a lens to focus an image of the beam on the spectrograph slit such that the direction of motion of the particles was parallel to the long dimension of the slit. At position A in Fig. 1, the particles in the beam have a velocity component away from the beam lens, and at B, they have a velocity component towards the beam lens; therefore the light arriving at A' is Doppler shifted towards the red, and that at B' toward the blue with corresponding shifts for points in between. The spectrograph used was stigmatic; that is, each recorded spectral line is made of a point to point image of the spectrograph slit. The slit just masks off everything outside the center of the beam, so each spectral line is an image of the center of the beam. Each of these beam images has a wavelength variation along its length, so each spectral line has a wavelength variation



Actual arrangement consisted of a reflection grating and an all-mirror spectrograph except for two quartz corrector plates in the camera.

SCHEMATIC OPTICAL ARRANGEMENT

Fig. 1

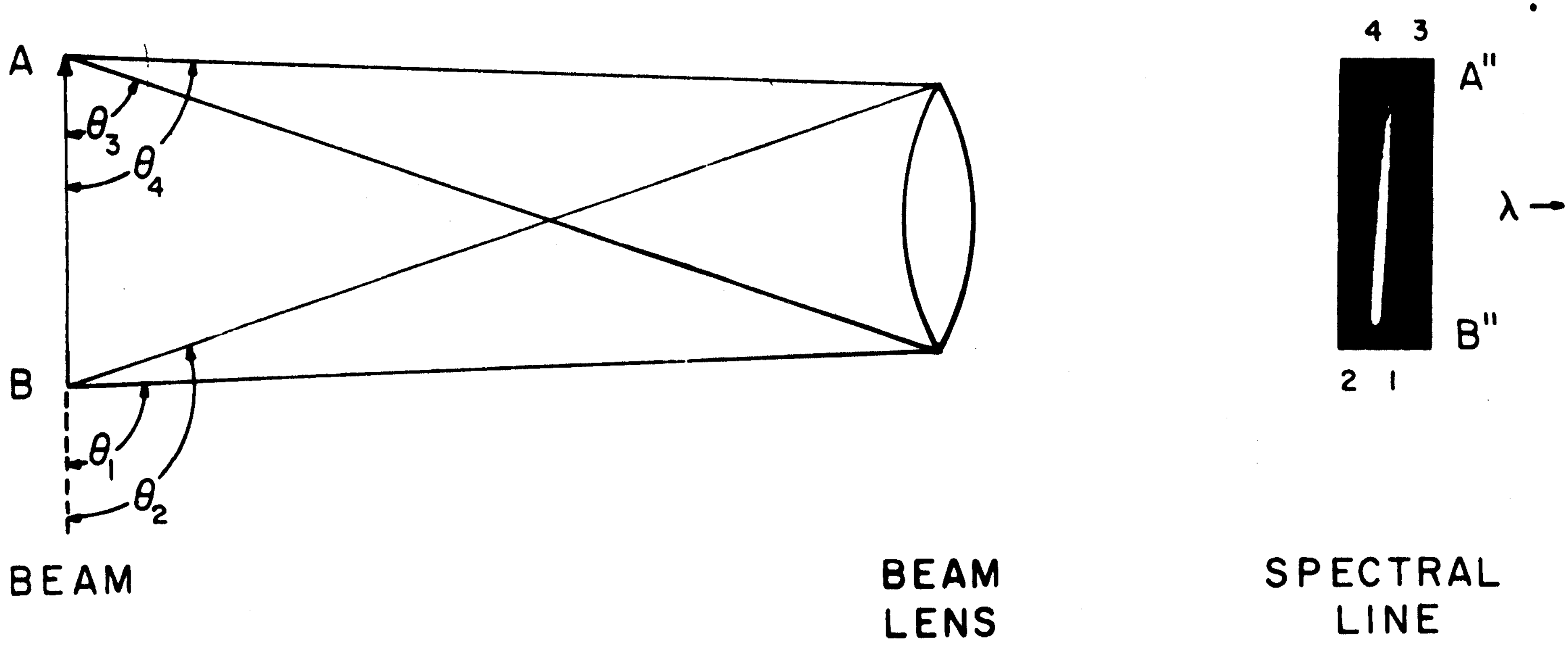
along its length and is slanted. Fig. 2 shows the limits of this Doppler shifting.

Referring to Fig. 2, if $\theta_1 = \theta_4$ and $\theta_2 = \theta_3$, the proper wavelength would appear to come from a point slightly on the foil side of the center of the beam. The position could be calculated, and the corresponding position on the slanted spectral line located. However, the beam length subtends an angle of 6.12° at the beam lens, and if an error of only 1° is made aligning the optical axis perpendicular to the beam, the proper wavelength would move up or down the spectral line by 1/6 of its length causing an instrumental error of about 1 Å in the proper wavelength. Instead, the true wavelength position was located experimentally by using a deuterium beam and locating the point on the D_α line which corresponds to the known value of D_α. With the dimensions of the optical arrangement and

$$\cos \theta_o = v/2c,$$

the proper wavelength position can be calculated for all other beams regardless of whatever alignment errors may have been made. The wavelength at the top (if visible) and bottom of each line was measured and the proper wavelength calculated from knowledge of its position on the line.

The shape of each spectral line should be a parallelogram, but each is triangular with one long side



$\lambda = \lambda_o \gamma (1 - \beta \cos \theta)$

For $\lambda = \lambda_o$, $\cos \theta_o = \dfrac{\gamma - 1}{\beta\gamma} \approx \tfrac{1}{2} \beta$ if $v \ll c$

θ is the angle between the forward direction of the beam and the forward direction of the photon,

λ_o is the proper wavelength, $\beta = v/c$, $\gamma = (1 - \beta^2)^{-1/2}$.

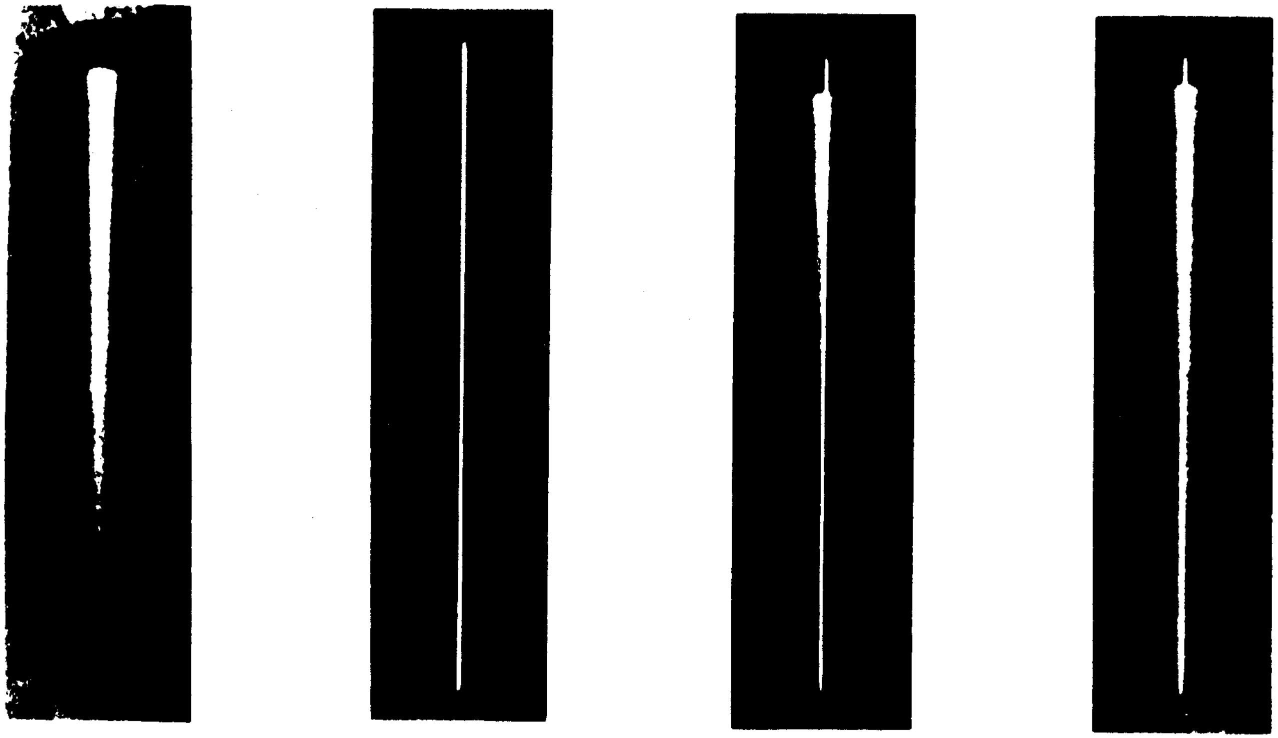
DOPPLER SHIFT

Fig. 2

sharp and the other fuzzy. This was due to an error in aligning the image of the beam exactly on and parallel to the spectrograph slit. In more recent experiments, this misalignment has been eliminated by the following method. A piece of photographic film was placed outside and against the spectrograph slit to record the image of the beam, Fig. 3a, and a light was put inside the spectrograph to illuminate the back of the slit and record its shadow on the film, Fig. 3b. When the film showed a picture as in Fig. 3c, triangular lines were obtained, and when the image of the beam was moved to show a picture as in Fig. 3d, the lines were parallelograms.

The various intensities of the lines are caused by the relative populations of the excited states and the different transition probabilities per second for the lines.

The intensity of each line decreases along its length because of the finite lifetime of the excited state. Each spectral line is an image of the beam in the light of a particular transition. As the particles move away from the foil, the excited states decay, reducing the populations of the sources of the lines. Cascades may complicate this variation of intensity with distance, but no line has yet been found which has an intensity increase. This intensity decrease causes many of the spectral lines to disappear before they reach maximum height. For these lines, the



BEAM IMAGE (a)

SLIT SHADOW (b)

INCORRECT ALIGNMENT (c)

CORRECT ALIGNMENT (d)

ALIGNMENT FILMS

FIG. 3

correction to be added to the wavelength measured at the bottom of the line was calculated from

$$\lambda_O - \lambda_B = \lambda_O\beta\gamma(\cos\theta_B - \cos\theta_O) \approx \lambda_B\beta\gamma(\cos\theta_B - \cos\theta_O)$$

where λ_O = the proper wavelength,

λ_B = the wavelength measured at the bottom of the line,

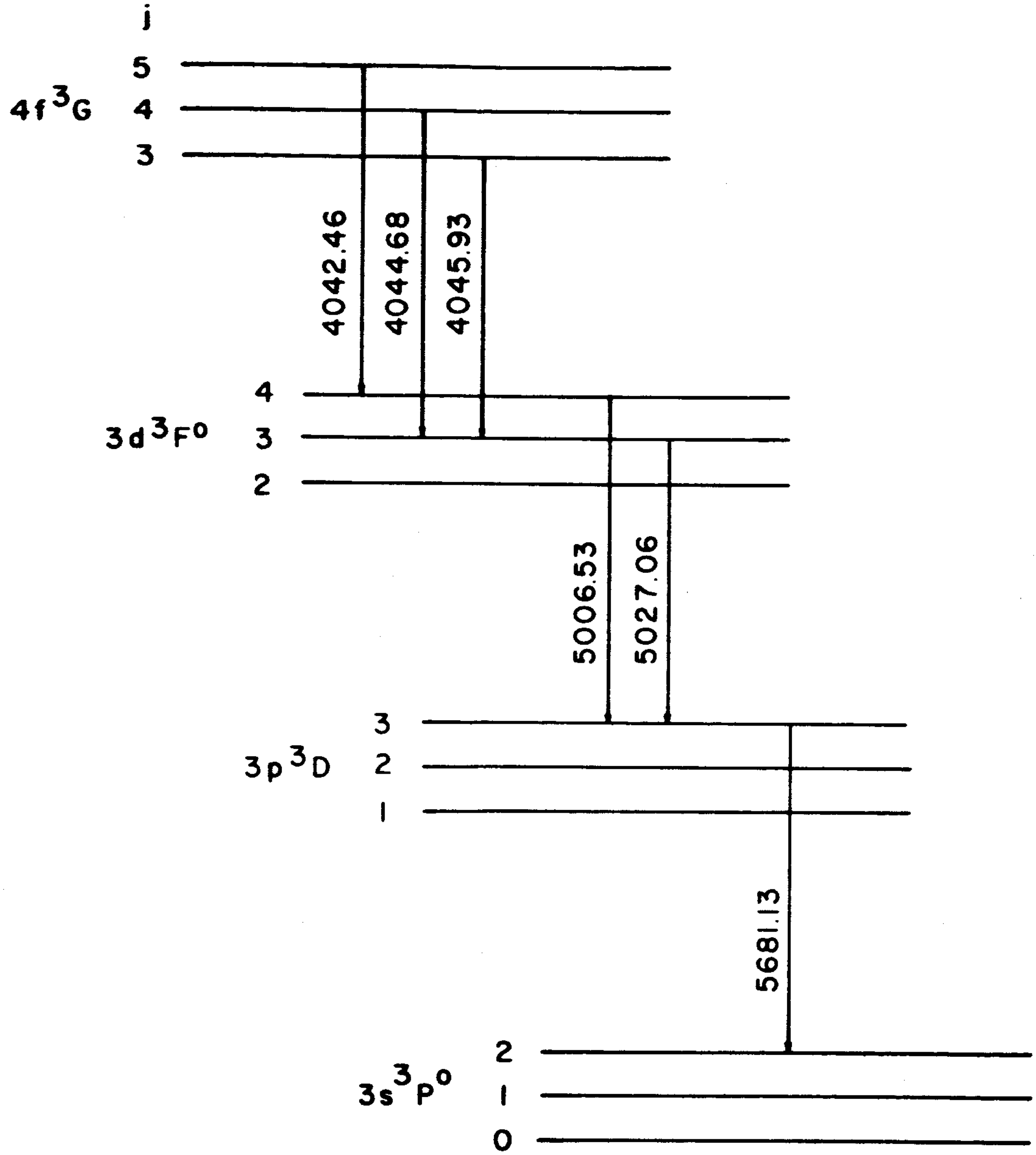
$\beta = v/c$,

$\gamma = (1 - \beta^2)^{-\frac{1}{2}}$,

and the other terms are defined in Fig. 2. Since everything except λ_B is constant for all lines on the plate, the coefficient of λ_B was calculated from the lines which do extend from top to bottom. This particular optical arrangement was used in spite of its alignment difficulties and slanted spectral lines because it permitted the measurement of the lifetimes of the excited states from the intensity decrease of the spectral lines.

To identify the sample spectral lines with those already in the literature, if, indeed, these lines have been produced and measured by other methods, two more difficulties need to be taken into account. One is the index of refraction of air. The sample spectra were measured in air, but the calculation of the accepted values of the wavelengths from the <u>Atomic Energy Levels</u> [6] tables gives their vacuum values. The other problem is simply the experimental error in the determinations of the wavelengths. This error was estimated as ± 3 Å between 3500 Å and 5000 Å and ± 2 Å from 5000 Å to 7000 Å from consideration of the reproducibility of the distance measurements, from the tightness of the dispersion curve, from the consistency of the results on the same line measured on different plates, and from the agreement of the deuterium wavelengths with the known values.

After all the possible identifications had been listed, cascades were used to restrict the selections further. For example, as shown in Fig. 4, the nitrogen line measured as λ 4043.2 Å could be identified as either λ 4042.46 Å ($3d^3F^o_4 - 4f^3G_5$ N II), λ 4044.68 Å ($3d^3F^o_3 - 4f^3G_3$ N II), or λ 4045.93 Å ($3d^3F^o_3 - 4f^3G_3$ N II). The λ 4042.46 Å line results from a transition to a state which can decay further and emit a line at λ 5006.53 Å ($3p^3D_3 - 3d^3F^o_4$ N II). This line at λ 5006.53 Å was also recorded in the spectrum and measured as λ 5007.1 Å. The other two possible identifications are transitions to a state which can decay further and emit a line at λ 5027.06 Å ($3p^3D_3 - 3d^3F^o_3$ N II), but this line was not observed in the spectrum. Both the observed λ 5006.53 Å and the unobserved λ 5027.06 Å line leave the atom in a state that can decay again and emit a line at λ 5681.13 Å ($3s^3P^o_2 - 3p^3D_3$ N II) which was also observed and measured as λ 5682.2 Å. From the $3s^3P^o_2$ state, further



A CASCADE IN N II

FIG. 4

transitions give rise to lines in the vacuum ultraviolet which was outside the observable range of the experiment.

The observation of the λ 5006.53 Å line and the failure to observe the λ 5027.06 Å line is not enough to identify the measured λ 4043.2 Å line as λ 4042.46 Å. An alternative explanation is that the $3d^3F_4^0$ state is created in the foil and then decays emitting the λ 5006.53 Å line; the measured λ 4043.2 Å line is actually λ 4044.68 Å; and the λ 5027.06 Å line is not seen because of a low transition probability per second. In fact, the transition probability for the λ 5027.06 Å line is only 1/23 that of the λ 4044.68 Å line [7]. However, the more likely explanation is that λ 4042.46 Å is the correct identification and the λ 5006.53 Å line and the λ 5681.13 Å line follow it.

The measured wavelengths and the identifications are listed in Tables 1 through 9.

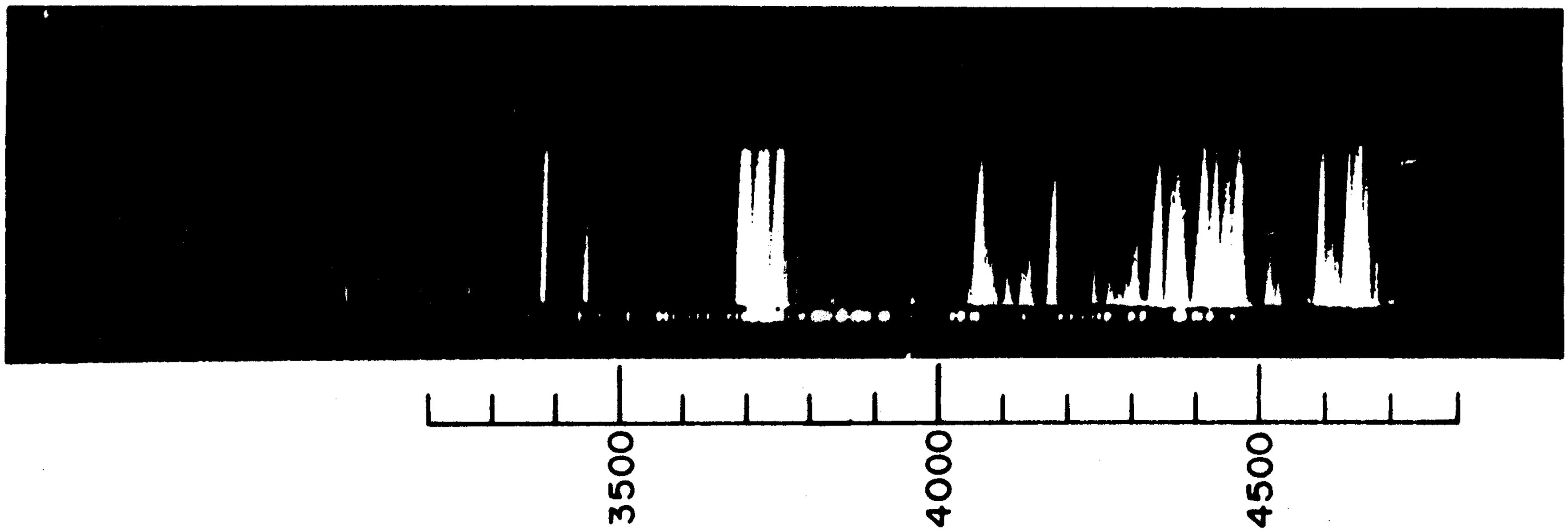


Plate 45 2 MV

Mass 44 CO_2^+

0.2 μamp. 33.6 min.

NRL 1/18/64

Fig. 5

Unknown #	Proper λ† (Å)	Identification (Å)
15	3849.5	0 I or II
16	3863.0	
17	3876.9	
18	3912.4	
19	3920.7	0 I or II
20	3934.3	3933.92 0 III $4p^3D_3-5s^3P_2^0$
21	3945.8	
22	3952.6	
23	3973.4	0 I or II
24	4060.1	0 I or II
25	4069.2	
26	4074.8	0 II or III

Beam contained C and O.

†Corrected to vacuo

WAVELENGTHS OF PLATE 45

TABLE 1

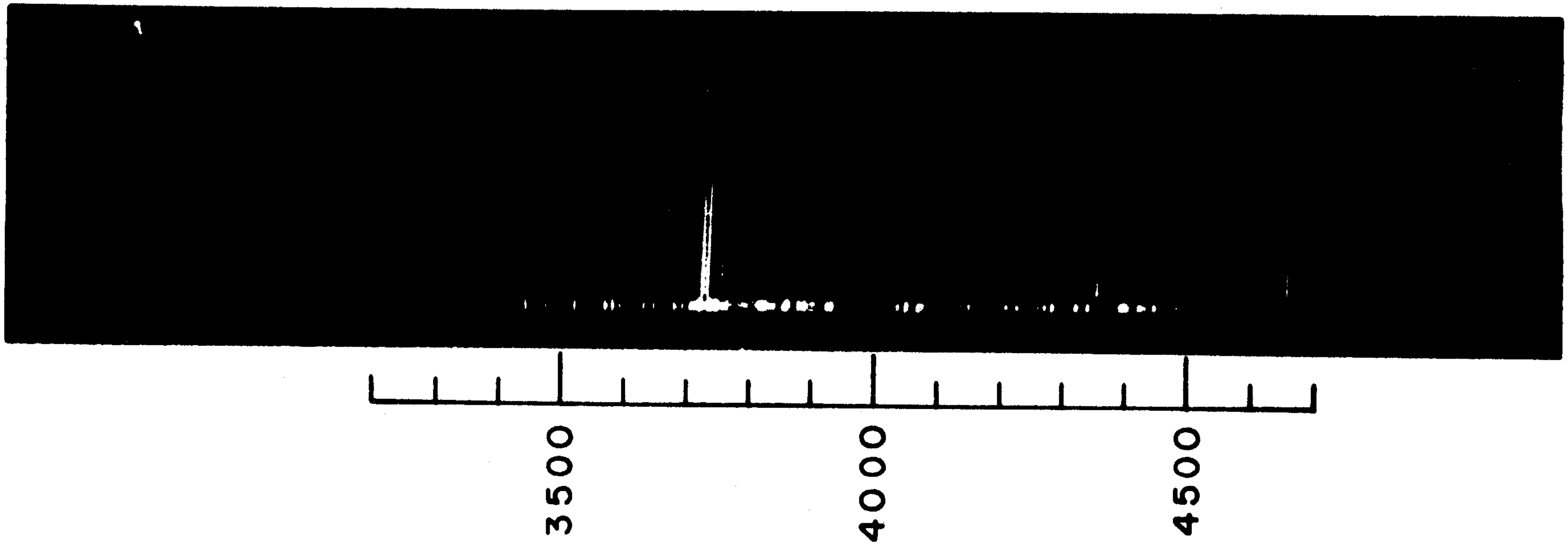


Plate 47 2 MV

Mass 32 O_2^+

0.25 μamp. 55.8 min.

NRL 1/18/64

Fig. 6

Unknown #	Proper λ† (Å)	Identification (Å)
1	3454.0	0 II or III
2	3704.5	0 I or III
3	3729.3	3728.39 0 II $3s^4P_{3/2}-3p^4S^o_{3/2}$
4	3739.0	0 II
5	3760.7	0 II or III
6	3776.8	3778.66 0 II $3p^3S^o_{3/2}-4s^4P_{1/2}$
7	3794.0	0 II or III
8	3850.5	0 I or II
9	3895.6	3894.61 0 II $3p^4D^o_{3/2}-3d^4P_{5/2}$
10	3906.8	3908.55 0 II $3p^4D^o_{5/2}-3d^4P_{5/2}$
11	3922.4	0 I or II
12	3934.3	3933.92 0 III $4p^3D_3-5s3P^o_2$
13	3971.0	0 I or II
14	4062.5	0 I or II
15	4074.8	0 II or III
16	4121.4	4120.52 0 III $4\ p^3S_1-5s^3P^o_2$
17	4128.4	0 I or II
18	4145.1	0 II
19	4156.2	4154.45 0 II $3p^4P^o_{3/2}-3d^4P_{5/2}$
20	4191.9	0 II
21	4255.5	0 II
22	4277.7	0 II
23	4285.5	0 II
24	4295.6	0 II or IV
25	4305.6	0 II
26	4349.7	0 II
27	4369.1	4368.13 0 II $3s^6P_{5/2}-3p^4P^o_{3/2}$
28	4379.7	0 II
29	4409.3	0 II
30	4416.5	4417.86 0 II $4s^4P_{1/2}-5p^6P^o_{3/2}$
31	4436.1	4438.49 0 II $4s^4P_{3/2}-5p^6P^o_{3/2}$

Beam contained 0.

WAVELENGTHS OF PLATE 47

TABLE 2

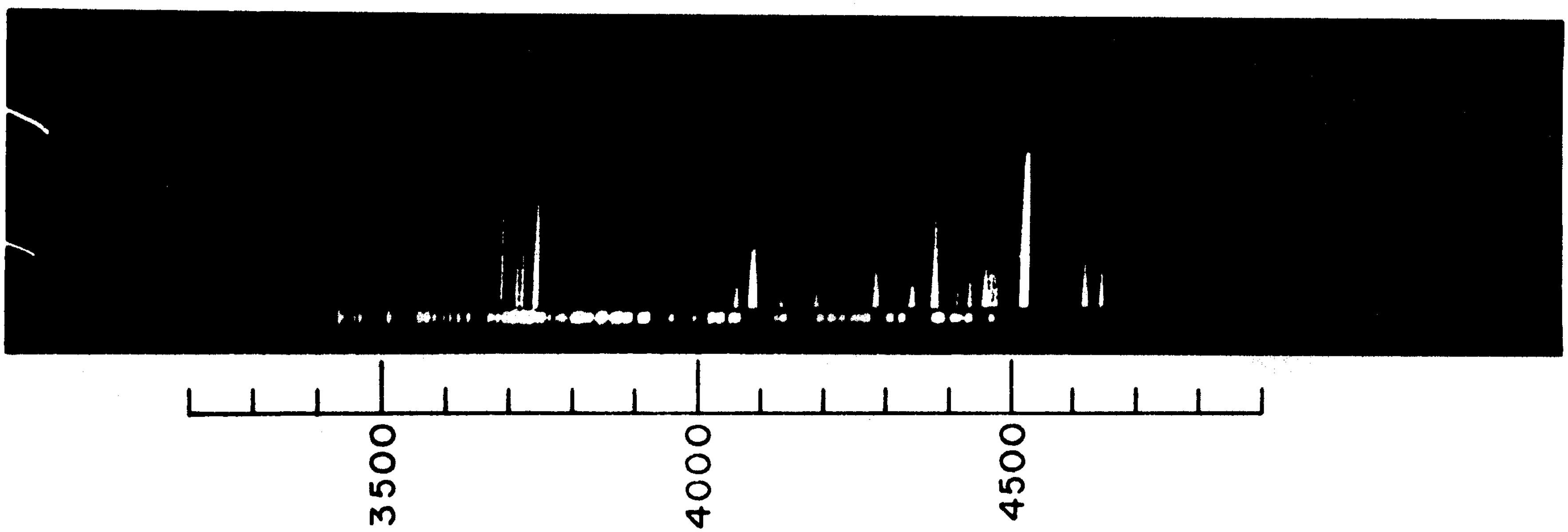


Plate 63 2 MV

Mass 30 NO^+

0.18 µamp. 29.5 min.

NRL 1/19/64

Fig. 7

Unknown #	Proper λ† (Å)	Identification (Å)
1	3392.9	O II or III
2	3483.3	
3	3704.4	O I or III
4	3728.7	3728.39 O II $3s^4P_{3/2}-3p^4S^o_{3/2}$
5	3738.4	O II or III or IV
6	3759.7	O II or III
7	3772.3	
8	3794.6	O II or III
9	3941.1	
10	3974.6	O I or II
11	3995.7	
12	4004.2	N II or III
13	4042.9	4042.46 N II $3d^3F^o_4-4f^3G_5$
14	4074.7	O II or III

Beam contained N and O.

WAVELENGTHS OF PLATE 63

TABLE 3

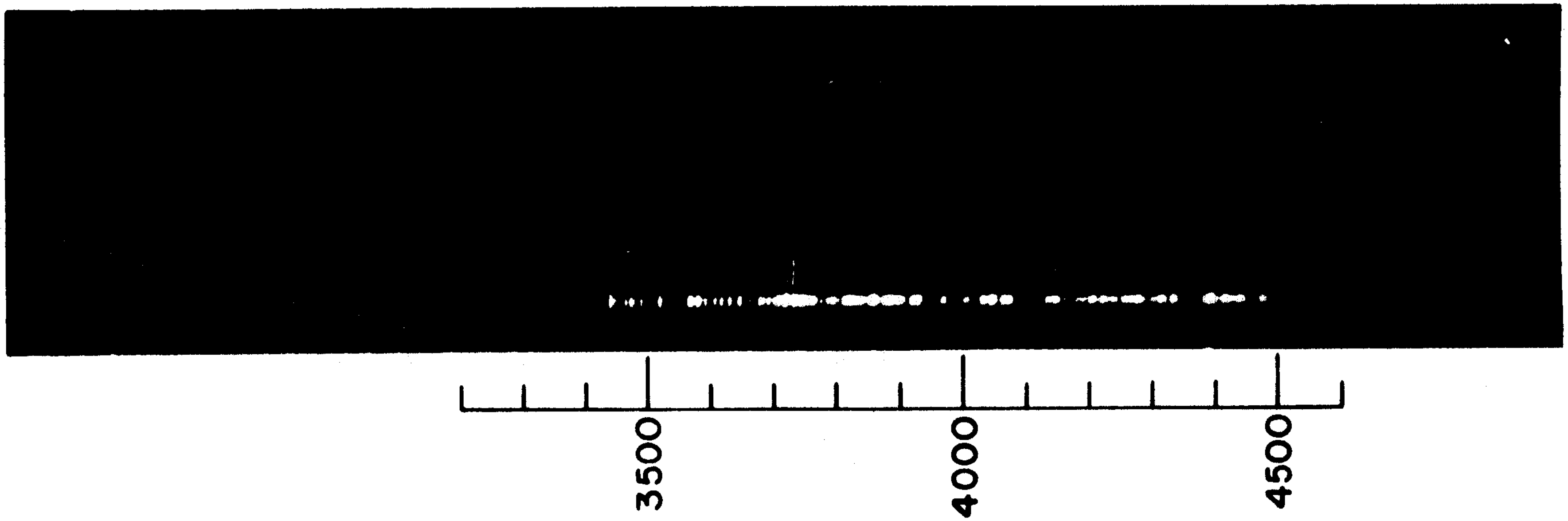


Plate 75 4 MV

Mass 32 O_2^+

0.12 µamp. 39.5 min.

HRL 1/20/64

Fig. 8

Unknown #	Proper λ† (Å)	Identification (Å)	
1	3395.9	O II or III	
2	3705.5	O I or III	
3	3729.8	3728.39 O II	$3s^4P_{3/2}-3p^4S^o_{3/2}$
4	3739.4	O II or IV	
5	3763.0	3763.70 O II	$3p^4S^o_{3/2}-4s^4P_{3/2}$
6	4343.9	O II	

Beam contained O

WAVELENGTHS OF PLATE 75

TABLE 4

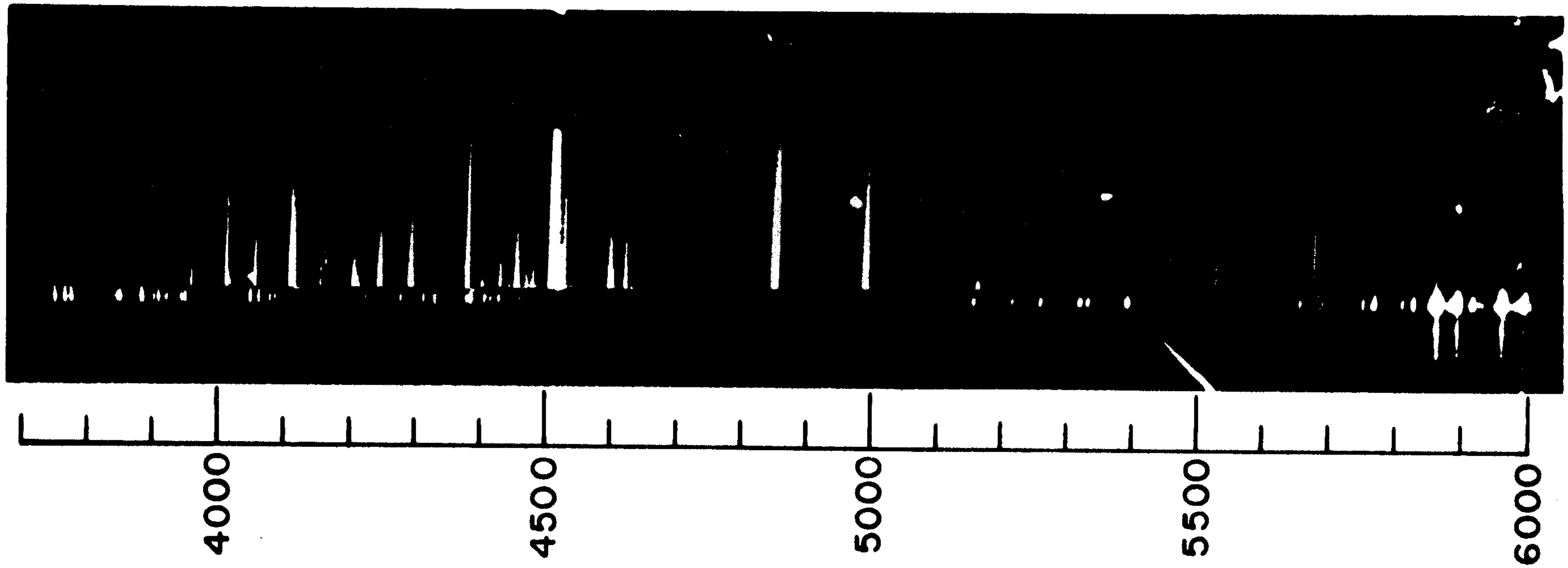


Plate 105 1.2 MV

Mass 28 CO^+, N_2^+

0.35 μamp. 18.9 min.

NRL 1/25/64

Fig. 9

Unknown #	Proper λ† (Å)	Identification (Å)
1	3775.1	3778.66 O II $3p\,^4S^o_{3/2}-3s\,^4P_{1/2}$
2	3941.3	N or O
3	3997.6	N or O
4	4005.1	N or O
5	4028.4	
6	4043.2	4042.46 N II $3d\,^3F^o_4-4f\,^3G_5$
7	4099.8	
8	4105.9	
9	4125.2	
10	4136.5	
11	4148.5	O I or II
12	4180.3	
13	4200.6	
14	4209.4	
15	4229.3	
16	4242.8	
17	4292.4	O II
18	4381.7	O II
19	4405.1	
20	4433.4	
21	4447.9	
22	4459.6	
32	5007.1	5006.53 N II $3p\,^3D_3-3d\,^3F^o_4$
33	5178.6	
34	5293.0	
35	5537.2	
36	5670.1	
37	5682.2	5681.13 N II $3s\,^3P^o_2-3p\,^3D_3$

Beam contained C, N, and O

WAVELENGTHS OF PLATE 105

TABLE 5

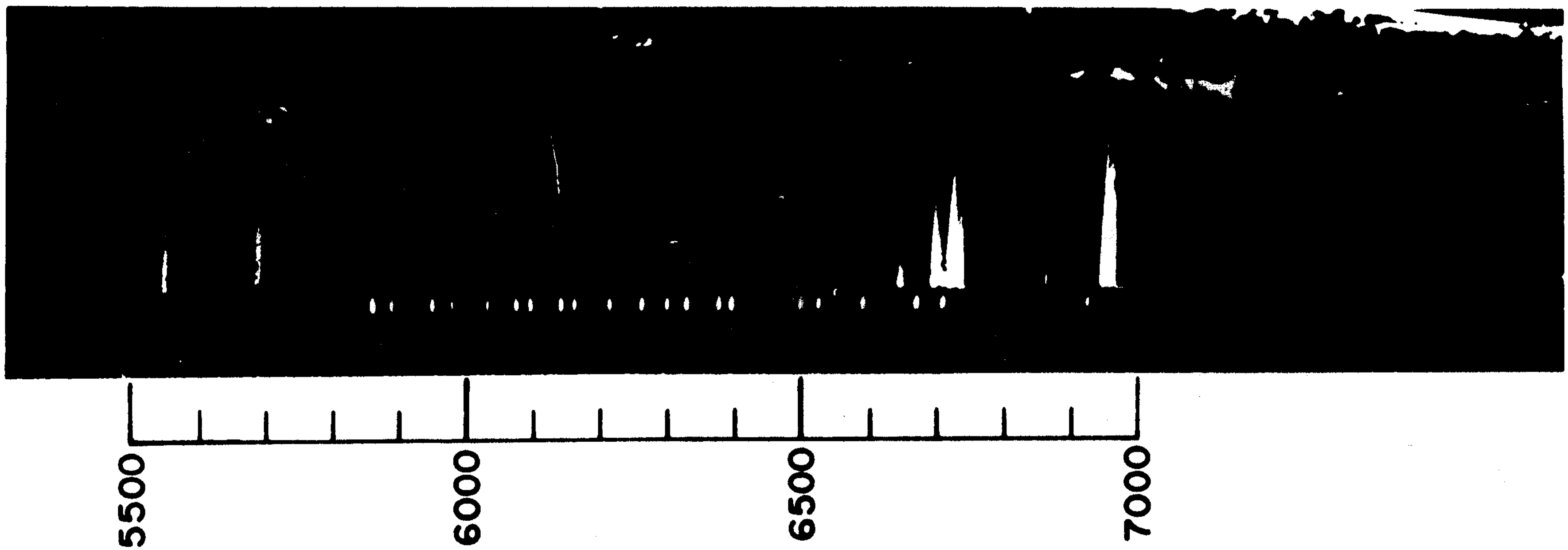


Plate 107 1.2 MV

Mass 28 CO^+, N_2^+

0.38 μamp. 17.9 min.

NRL 1/25/64

Fig. 10

Unknown #	Proper λ† (Å)	Identification (Å)
1	5965.5	
2	6016.4	C
3	6158.3	O I or C
4	6166.4	N II or C
5	6613.7	N II or C
6	6640.3	O II or C
7	6661.3	C
8	6708.8	O II or C
9	6735.5	C
10	6750.1	C
11	6876.0	O II or C

Beam contained C, N, and O

WAVELENGTHS OF PLATE 107

TABLE 6

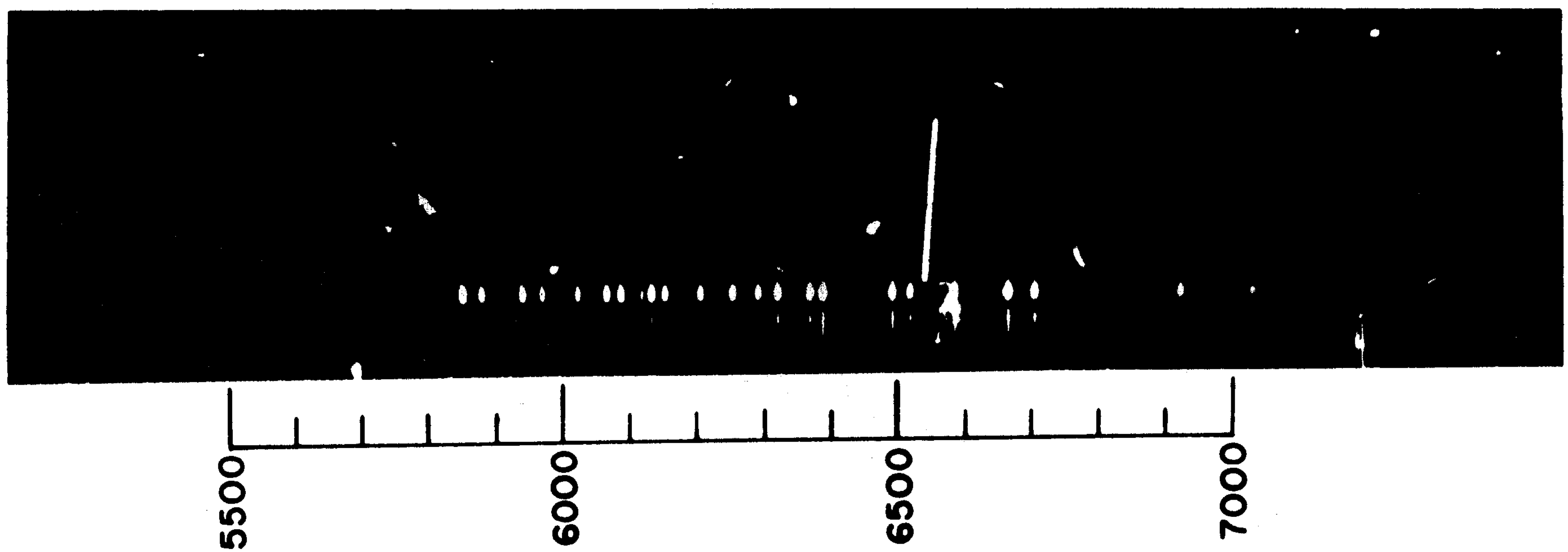


Plate 111 0.9 MV

Mass 6 D_3^+

0.3 μamp. 95 min.

NRL 1/27/64

Fig. 11

Unknown #	Proper λ† (Å)	Identification (Å)
1	6563.5	6562.8 D_{α}

Beam contained D.

WAVELENGTHS OF PLATE 111

TABLE 7

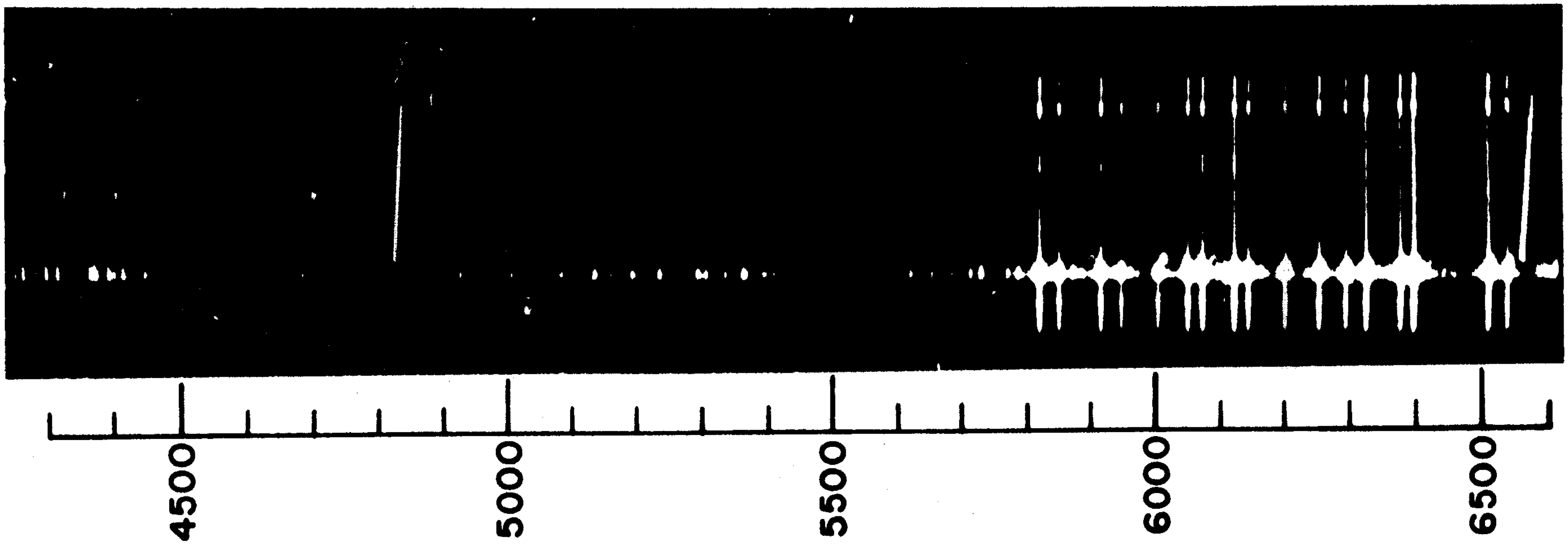


Plate 122 0.9 MV

Mass 6 D_3^+

0.3 µamp. 51.7 min.

NRL 1/27/64

Fig. 12

Unknown #	Proper $\lambda^{\dagger}$ (Å)	Identification (Å)
1	4340.9	4340.5 D_{γ}
2	4860.6	4861.3 D_{β}
3	6561.3	6562.8 D_{α}

Beam contained D.

WAVELENGTHS OF PLATE 122

TABLE 8

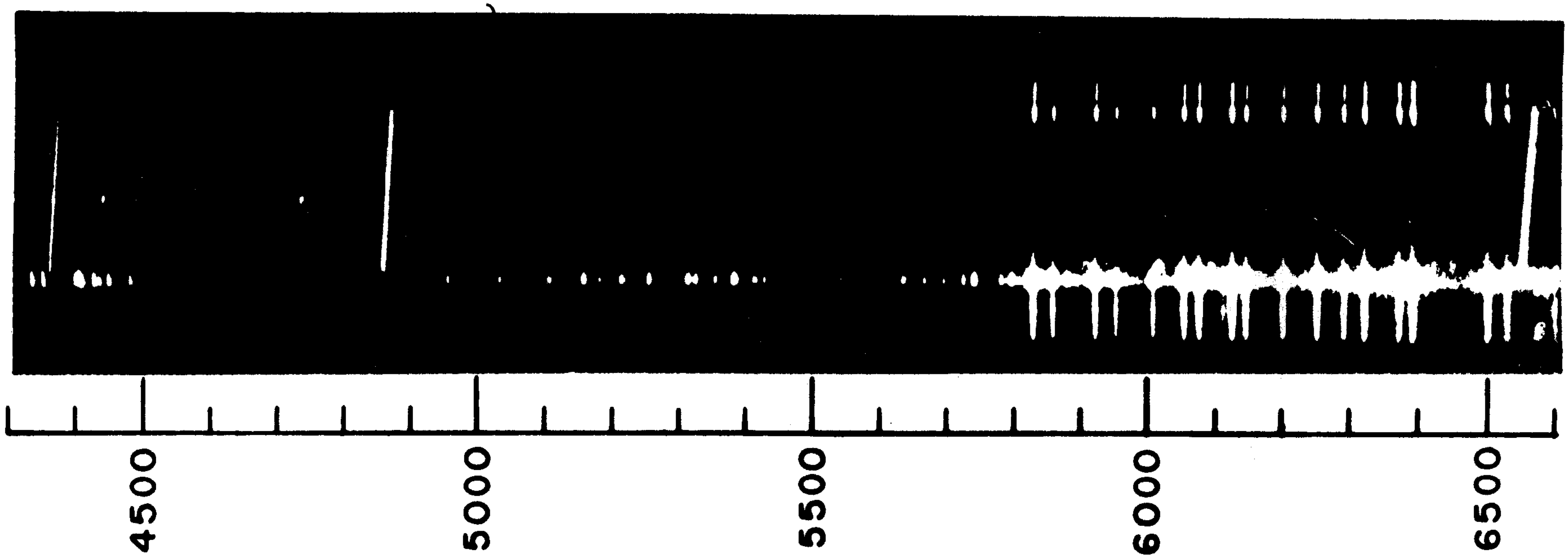


Plate 123 0.9 MV

Mass 6 D_2^+

0.35 µamp. 126.1 min.

NRL 1/27/64

Fig. 13

Unknown #	Proper $\lambda^{\dagger}$ (Å)	Identification (Å)
1	4341.4	4340.5 D_{γ}
2	4862.7	4861.3 D_{β}
3	6562.9	6562.8 D_{α}

Beam contained D.

WAVELENGTHS OF PLATE 123

TABLE 9

APPENDIX

	λ (Å)	Δλ (Å)	d (μ)	Disp. (Å/mm)	
			1655		
			1511		
u1			1488		
			1288		
u2			1267		
u2'			1220		
			1193		
			1020		
	3440.8	129.3	867	149.1	(doublet 3440.61, 3440.91)
			822		
u3			822		
u4			790		
			783		
	3465.86	104.24	699	149.1	
			646		
			596		
	3490.58	79.52	536	148.3	
			476		
	3521.26	48.84	331	147.5	
	3570.10	0	0		
	3581.20	11.10	82		
			167		
	3608.86	38.76	264	146.8	
	3618.77	48.67	337	144.4	
	3631.46	61.36	424	144.7	
	3647.84	77.74	530	146.6	
			646		
			752		
			848		
u5			852		
u6			894		
u5'			895		
u6'			929		
	3705.57	135.47	929	145.8	
u7			957		
u7'			998		
	3719.93	149.82	1021	146.7	
u8			1024		
u8'			1044		
u9			1063		
u9'			1097		
u10			1121		
	3734.87	164.77	1136	145.0	
u11			1256		
u11'			1284		

(continued)

MEASUREMENTS OF PLATE 45

TABLE 10

	λ	Δλ	d	Disp.	
u12			1284		
			1286		
u12'			1319		
	3767.19	197.09	1341	146.9	
u13			1378		
u14			1494		
	3825.88	255.78	1748	146.3	
	3834.22	264.12	1809	146.0	
	3841.05	270.95	1856	145.9	
u15	3846.4		1890	(146.2)	
	3859.91	289.81	1984	146.0	
u16	3859.9		1984	(146.1)	
u17	3873.8		2079	(146.1)	
	3878.30	308.20	2108	146.2	(doublet 3878.02, 3878.57)
	3886.28	316.18	2164	146.1	
	3899.71	329.61	2254	146.2	
u18	3909.3		2325	(145.9)	
u19	3917.6		2382	(145.9)	
	3921.56	351.46	2412	145.7	(doublet 3920.26, 3922.91)
	3929.11	359.01	2458	146.0	(doublet 3927.92, 3930.30)
u20	3931.2		2477	(145.8)	
u21	3942.7		2556	(145.8)	
	3969.26	399.16	2737	145.8	
u22	3949.5		2604	(145.7)	
u23	3970.3		2747	(145.7)	
	4030.76	460.66	3178	144.9	
	4045.81	475.71	3724	145.2	
u24	4056.9		3353	(145.2)	
	4063.60	493.50	3394	145.4	
u25	4065.5		3414	(145.1)	
	4071.74	501.64	3449	145.4	
u25'	4071.4		3455	(145.1)	
u26	4071.4		3455	(145.1)	
u26'	4076.8		3492	(145.1)	

	λ (Å)	Δλ (Å)	d (μ)	Disp. (Å/mm)	
	3440.81	884.96	6096	145.4	(doublet 3440.61, 3440.91)
	3447.28	878.49	6053	145.1	
u1	3450.4		6033	(145.1)	
	3453.9		6009	(145.1)	
	3465.86	859.90	5929	145.0	
	3475.6	850.2	5874	144.6	
	3485.34	840.43	5821	144.3	
	3490.58	835.18	5765	144.8	
	3497.48	828.29	5709	145.0	(doublet 3497.11, 3497.89)
	3521.26	804.50	5557	144.7	
	3570.10	755.66	5227	144.5	
	3581.20	744.56	5151	144.5	
	3594.64	731.13	5068	144.2	
	3608.86	716.91	4960	144.5	
	3618.77	707.09	4900	144.3	
	3631.46	694.30	4810	144.3	
	3647.84	677.92	4699	144.2	
			4589		
	3679.91	645.86	4495	143.6	
	3687.46	638.31	4439	143.7	
	3694.53	631.24	4385	143.9	(doublet 3694.01, 3695.05)
u2	3699.2		4351	(144.0)	
	3705.57	620.20	4304	144.1	
u2'	3709.3		4294	(143.6)	
	3719.93	605.84	4204	144.1	
u3	3725.7		4170	(143.9)	
u3'	3731.7		4131	(143.8)	
u4	3735.2		4107	(143.8)	
	3737.13	588.64	4094	143.8	
u4'	3741.7		4062	143.8	
	3746.05	579.72	4026	143.9	
u5	3756.6		3961	(143.7)	
	3758.23	567.54	3949	143.7	
u5'	3763.8		3904	(143.9)	
	3767.19	558.57	3896	143.3	
u6	3772.5		3853	(143.6)	
			3821		
			3743		
u7	3789.1		3737	(143.6)	
u7'	3798.0		3678	(143.5)	
			3671		
	3834.22	491.55	3432	143.2	
	3841.05	484.72	3380	143.4	
u8	3846.1		3347	143.3	
	3859.91	465.86	3254	143.1	

(continued)

MEASUREMENTS OF PLATE 47

TABLE 11

	λ	Δλ	d	Disp.	
	3878.30	447.47	3124	143.2	(doublet 3878.02, 3878.57)
	3886.28	439.49	3071	143.1	
u9	3891.2		3037	(143.1)	
u10	3902.3		2961	(143.0)	
u11	3917.9		2852	(143.0)	
	3921.56	404.19	2826	143.0	(doublet 3920.26, 3922.91)
	3929.11	396.66	2773	143.0	(doublet 3927.92, 3930.30)
u12	3929.8		2752	(142.9)	
	3969.26	356.51	2495	142.8	
u13	3970.5		2488	(142.8)	
	4005.		2246	142.6	
	4030.76	295.28	2057	143.5	
	4045.81	279.96	1967	142.3	
u14	4057.7		1884	(142.3)	
	4063.60	262.17	1843	142.2	
u14'	4066.4		1823	(142.3)	
u15	4070.1		1795	(142.2)	
	4071.74	254.13	1785	142.3	
u15'	4078.6		1738	(142.2)	
u16	4116.7		1471	(142.1)	
u17	4123.7		1423	(142.0)	
	4132.06	193.71	1361	142.3	
u18	4140.4		1306	(141.9)	
	4143.87	181.90	1284	142.1	
u19	4151.5		1229	(141.8)	
u20	4187.2		979	(141.5)	
u20'	4195.5		921	(141.4)	
	4200.17		880	142.7	(triplet 4198.31, 4199.10, 4202.03)
	4217.55	108.22	769	140.7	
			642		
u21	4250.6		533	(141.0)	
	4250.79	74.98	528	142.0	
	4260.48	65.29	463	141.0	
	4271.77	54.10	384	140.8	
u22	4272.8		376	(140.8)	
u23	4280.6		321	(140.8)	
u24	4290.7		249	(140.7)	
u25	4300.7		178	(140.6)	
	4307.91	17.86	128	139.5	
	4325.77	0	0		
u26	4344.7		135	(140.3)	
u26'	4353.7		199	(140.2)	
u27	4364.3		275	(140.1)	
u27'	4372.9		337	(140.0)	
u28	4374.8		350	(140.0)	
	4375.93	50.16	357	140.5	
	4383.55	57.78	412	140.2	
u28'	4383.5		413	(139.9)	
u29	4404.3		562	(139.7)	
	4404.75	78.98	566	139.5	
u30	4411.3		613	(139.6)	

(continued)

	λ	Δλ	d	Disp.
u29'	4413.2		626	(139.6)
	4415.12	89.35	642	139.1
u30'	4420.8		681	(139.5)
	4427.31	101.54	728	139.4
u31	4431.3		757	(139.4)
u31'	4439.7		818	(139.3)

	λ (Å)	Δλ (Å)	d (μ)	Disp. (Å/mm)	
			2186		
			2036		
			1815		
u1	3382.8		1787	(148.3)	
			1719		
			1551		
	3440.81	207.04	1395	148.4	(doublet 3440.61, 3440.91)
	3447.28	200.56	1354	148.1	
			1231		
	3465.86	181.98	1228	148.1	
	3476.08	171.76	1175	146.1	(doublet 3475.45, 3476.70)
u2	3479.2		1140	(147.9)	
	3485.34	162.50	1125	144.4	
	3490.58	157.26	1063	147.9	
	3497.50	150.34	1006	149.4	(doublet 3497.11, 3497.89)
	3521.26	126.58	861	147.0	
	3570.10	77.74	532	146.1	
	3581.20	66.64	445	149.7	
	3594.64	53.20	366	145.6	
	3608.86	38.98	261	149.3	
	3618.77	29.07	196	148.3	
	3631.46	16.38	106	154.5	
	3647.84	0	0		
			113		
	3679.91	32.07	221	145.1	
	3687.46	39.40	268	147.0	
	3694.53	46.69	319	146.3	(doublet 3694.0[illegible], 3695.05)
u3	3700.1		356	(146.9)	
	3705.57	57.73	399	144.7	
u3'	3707.4		401	(146.9)	
	3709.25	61.41	441	139.3	
	3719.93	72.09	498	144.7	
u4	3724.3		521	(146.8)	
u4'	3732.3		575	(146.8)	
u5	3734.0		587	(146.8)	
u5'	3742.0		642	(146.7)	
	3737.13	89.29	608	146.8	
	3746.05	98.21	680	144.4	
u6	3755.0		731	(146.6)	
	3758.23	110.39	756	146.0	
u6'	3763.7		790	(146.6)	
	3767.19	119.35	810	147.3	
u7	3768.8		818	(146.6)	

(continued)

MEASUREMENTS OF PLATE 63

TABLE 12

	λ	Δλ	d	Disp.	
u8	3790.1		971	(146.5)	
			1183		
	3825.88	178.04	1220	145.9	
	3834.22	186.38	1279	145.7	
	3841.05	193.21	1325	145.8	
	3859.91	212.07	1449	146.3	
	3878.30	230.46	1576	146.2	(doublet 3978.02, 3878.57)
	3886.28	238.44	1633	146.0	
	3899.71	251.87	1723	146.1	
	3921.56	273.74	1875	145.9	(doublet 3920.26, 3922,91)
	3929.11	281.27	1930	145.7	
u9	3936.4		1979	(145.8)	
u10	3969.8		2211	(145.6)	
	3969.26	321.42	2207	145.6	
u11	3990.9		2356	(145.6)	
u12	3999.4		2416	(145.5)	
	4005.25	357.41	2454	145.6	
	4030.76	382.92	2644	144.8	
u13	4038.1		2686	(145.3)	
	4045.81	397.97	2736	145.4	
	4063.60	415.76	2844	146.1	
u14	4069.8		2906	145.2	
	4071.74	423.90	2906	145.8	

	λ (Å)	Δλ (Å)	d_1 (μ)	d_2 (μ)	d_3 (μ)	d_4 (μ)	Disp. (Å/mm)	
			2182	2185	2184	2188		
			2036	2036	2032	2039		
			1815	1821	1815	1820		
			1789	1793	1790	1791		
u1	3391.0	256.9		1731		1732	(148.3)	
	3392.66	255.18	1721	1721	1718	1723	148.27	
	3413.13	134.71	1554	1553	1552	1555	151.03	
	3440.81	207.03	1399	1399	1399	1399	148.44	(dou. 3440.61, 3440.91)
	3444.52	203.32	1352	1354	1350	1356	150.32	(dou. 3443.88, 3445.15)
	3452.28	195.56	1304	1306		1306	150.16	
	3465.86	181.98	1225	1228	1221	1231	148.43	
	3483.01	164.83	1122	1120	1123	1126	146.64	
	3490.58	157.26	1064	1062	1065	1061	147.93	
	3500.57	147.27	1000	1001	1003	1005	146.97	
	3521.26	126.59	859	860	861	862	147.18	
	3580.10	77.74	525	525	523	530	147.79	
	3581.20	66.64	448	449	448	451	148.41	
	3584.64	53.20	365	366	364	370	145.35	
	3608.86	38.98	261	265	259	265	148.77	
	3618.77	29.07	195	197	193	196	149.84	
	3631.46	16.38	107	108	108	109	151.66	
	3647.84	0	0	0	0	0		
			109	108		108		
	3679.91	32.07	218	218	219	217	147.11	
	3686.00	38.16	261	259	261	257	147.33	
	3694.01	46.17	315	313	314	312	147.03	(dou. 3694.01, 3695.05)
u2	3700.3		358	355	358	355	(147.0)	
	3705.57	57.73	395	395	399	395	145.78	
u2'	3710.8		429	429	429	424	(147.4)	
			446	439	453	440		
	3722.56	74.72	493	494	494	490	151.56	
u3	3724.4	76.55	524	517	520	514	(147.5)	
u4	3733.8	85.96	584	585	579	582	(147.7)	
u3'	3735.3		598	589	595	588	(147.7)	
	3737.13	89.29	606	606	599	604	147.83	
u4'	3745.1		656	658	659	654	(148.0)	
	3749.49	101.65	679	676	678	678	149.92	
u5	3757.5		737	734	738	732	(149.2)	
	3758.23	110.39	749	751	750	748	149.18	
	3767.19	119.35	796	795	794	799	149.93	
u5'	3768.6		811	803	803	813	(149.5)	
			1143	1135	1140	1139		
	3825.88	178.04	1199	1194	1199	1195	148.86	

(continued)

MEASUREMENTS OF PLATE 75

TABLE 13

	λ	Δλ	d_1	d_2	d_3	d_4	Disp.	
	3834.22	186.38		1254		1255	148.62	
	3841.05	193.21	1311	1306	1312	1305	147.71	
	3859.91	212.07	1445	1443	1450	1441	146.76	
	3878.25	230.41	1568	1563	1569	1568		(dou. 3878.02, 3878.57)
	3886.28	238.44	1627	1629	1630	1631	146.37	
	4307.91	660.07	4584	4575	4585	4572	144.15	
	4315.09	667.25	4696	4709	4710	4693	141.90	
	4325.76	677.92		4733		4730	143.26	
u6	4337.6		4809	4808	4811	4811	(143.5)	
	4375.93	728.09	5057	5055	5060	5054	144.00	
	4383.55	735.31	5119	5119	5116	5111	143.72	

	λ (Å)	Δλ (Å)	d_1 (μ)	d_2 (μ)	Disp. (Å/mm)	
	3722.56	1608.22	11118	11114	144.67	
	3737.13	1593.65	11006	11008	144.78	
	3748.26	1582.52	10938	10934	144.70	
	3758.23	1572.55	10862	10862	144.77	
	3767.19	1563.58	10814	10816	144.57	
u1	3771.4		10783	10785	(144.6)	
	3795.00	1535.78		10623	144.57	
	3820.43	1510.35		10440	144.66	
	3825.88	1504.90		10404	144.64	
	3834.22	1496.56	10347	10346	144.65	
	3841.05	1489.73	10298	10298	144.66	
	3859.91	1470.87	10172	10172	144.59	
	3878.25	1452.48	10044	10046	144.59	
	3886.28	1444.50	9992	9991	144.56	
	3899.71	1431.07	9905	9902	144.49	
	3921.56	1409.20	9753	9750	144.50	(doublet 3920.26, 3922.91)
	3929.11	1401.67	9702	9699	144.50	(doublet 3927.92, 3930.30)
u2	3937.5		9641	9642	(144.5)	
	3969.26	1361.52	9431	9427	144.39	
u3	3993.7		9266		(144.3)	
u4	4001.2		9216	9212	(144.3)	
	4005.25	1325.53	9190		144.24	
u5	4024.5		9059		(144.2)	
	4030.76	1300.29	9006	9004	144.39	
u6	4039.3		8953	8950	(144.2)	
	4045.81	1284.97	8914	8914	144.15	
	4063.60	1267.18	8794	8795	144.09	
	4071.74	1259.04	8738	8731	144.15	
u7	4095.8		8575	8577	(144.0)	
u8	4101.9		8535	8534	(144.0)	
u9	4121.2		8400		(144.0)	
	4132.06	1198.72	8332	8326	143.92	
u10	4132.5		8328	8326	(143.9)	
	4143.87	1186.91	8248	9247	143.90	
u11	4144.5		8243	8245	(143.9)	
u12	4176.2		8028	8029	(143.8)	
u13	4196.5		7888	7888	(143.8)	
	4200.17	1130.61	7862	7867	143.77	(triplet 4198.31, 4199.10, 4202.03)
u14	4205.3		7832		(143.7)	
	4219.		7758	7754		
u15	4225.2		7694		(143.7)	
u16	4238.7		7604	7606	(143.6)	

(continued)

MEASUREMENTS OF PLATE 105

TABLE 14

	λ	Δλ	d_1	d_2	Disp.
	4250.79	1079.99	7522	7524	143.55
	4260.48	1070.30	7455	7455	143.56
	4271.77	1059.01	7377	7378	143.53
u17	4287.8		7266	7269	(143.5)
u17'	4295.6		7214		(143.5)
	4307.91	1022.87	7131	7134	143.41
	4325.77	1005.01	7012	7009	143.36
	4375.93	954.85	6665	6666	143.24
u18	4377.7		6658	6654	(143.2)
	4383.55	947.23	6613	6615	143.43
u18'	4384.2		6610		
u19	4400.8		6496	6491	(143.2)
	4404.75	926.03	6469	6473	143.10
	4415.12	915.66	6401	6401	143.02
	4427.31	903.47	6308	6312	143.18
u20	4429.1		6310	6296	(143.1)
u21	4443.6		6203	6205	(143.0)
u22	4455.3		6122	6122	(143.0)
	4460.38	870.40	6085	6081	143.09
	4469.38	861.40	6011	6016	143.23
u23			5936	5942	
u24			5733	5721	
u24'			5678		
u25			5596	5601	
u25'			5549		
	4556.12	774.66	5448	5447	142.19
u26			5101	5090	
u27			4932	4931	
u28			4851	4848	
u29			3613		
u30			3408		
u31			3309		
u31'			3258		
	4890.77	440.01	3110	3112	141.43
	4919.85	410.93	2907	2901	141.50
	4957.56	373.17	2648	2648	140.92
	5006.13	324.65	2313		140.35
u32	5002.8		2337		(140.4)
u32'	5009.4		2280		(141.0)
	5939.26	291.52	2083	2080	140.01
	5079.50	251.28	1784	1779	141.01
	5110.46	220.32	1524	1523	144.56
	5167.49	163.29	1159	1156	141.01
u33	5173.6		1112		(141.4)
	5191.92	138.86	978		141.98 (doublet 5191.47, 5192.36)
	5204.58	126.20	897		140.69

(continued)

	λ	Δλ	d_1	d_2	Disp.
	5227.19	103.59	740	736	140.36
	5269.54	60.56	428	427	141.49
u34	5287.9		298		(143.9)
	5330.78	0	0	0	
	5341.09	10.31	87	87	118.50
	5371.49	40.71	303	303	134.35
	5400.56	69.78	512	511	136.28
	5434.53	103.75	742	736	140.34
	5446.92	116.14	850	851	136.63
	5455.61	124.83	916		136.27
u35	5531.4		1467	1472	(136.5)
u35'	5541.2		1539		(136.7)
	5562.77	231.99	1687	1694	136.79
	5656.66	325.88	2382	2383	136.80
u36	5664.6		2439	2441	(136.8)
u37	5676.8		2530	2632	(136.7)
u37'	5685.4		2594		(136.7)
	5689.82	359.04	2626	2626	136.72
	5719.22	388.44	2846	2945	136.48
	5748.30	417.52	3065	3063	136.26
	5764.42	433.64	3188	3187	136.02
	5804.45	473.67	3487	3485	135.87
	5820.15	489.37	3608	3602	135.74
	5852.49	521.71	3850	3843	135.65
	5881.89	551.11	4069	4064	135.54
			4238		
	5944.83	614.05	4551	4546	135.01

	λ (Å)	Δλ (Å)	d_1 (μ)	d_2 (μ)	Disp. (Å/mm)
	5852.49	481.94	3419	3418	141.00
	5881.89	452.54	3218	3216	140.67
	5944.83	389.60	2769	2767	140.75
u1	5959.6		2664	2673	(140.5)
	5975.53	358.90	2552	2554	140.57
u2	6010.4		2309	2307	(140.4)
	6029.99	304.44	2172	2169	140.29
	6074.34	260.09	1857	1856	140.13
	6096.16	238.27	1706	1701	139.82
	6128.45	205.98	1471		140.02
	6143.06	191.37	1369	1363	140.09
u3	6152.2		1300	1303	(140.0)
u4	6160.3		1243	1246	(140.0)
	6163.59	170.84	1222	1221	139.80
	6217.28	117.15	837	837	139.96
	6266.49	67.94	488	489	139.22
	6304.79	29.64	214	213	138.50
	6334.43	0	0	0	
	6382.99	48.56	349	349	139.14
	6402.25	67.82	484	486	139.83
	6506.53	172.10	1237	1239	139.01
	6532.88	198.45	1431	1428	138.77
	6598.95	254.52	1911	1912	138.34
u5	6607.1		1965	1975	(138.4)
u6	6633.7		2164	2163	(138.3)
u7	6654.6		2318	2316	(138.2)
	6678.28	343.85	2490	2492	138.09
u8	6702.1		2676	2671	(137.9)
	6717.04	382.61	2776	2776	137.79
u9	6728.8		2862	2861	(137.8)
u10	6743.4		2972	2967	(137.7)
u11	6869.1		3903	3897	(137.1)
	6929.47	595.04	4351	4351	136.75

MEASUREMENTS OF PLATE 107

TABLE 15

	λ (Å)	Δλ (Å)	d_1 (μ)	d_2 (μ)	d_3 (μ)	d_4 (μ)	Disp. (Å/mm)
	5881.89	148.10	1046	1046	1048	1050	141.39
	5944.83	85.16	602	602	601	601	141.60
	5975.53	54.46	389	386	388	386	140.65
	6029.99	0	0	0	0	0	
	6074.34	44.35	314	316	314	313	141.15
	6096.16	66.17	473	476	470	473	139.89
	6128.45	98.46	706	703	702	700	140.09
	6143.06	113.07	805	804	804	807	140.45
	6163.59	133.60	950	954	955	949	140.33
	6217.28	187.29	1334	1338	1334	1335	140.27
	6266.49	236.50	1687	1688	1690	1687	140.10
	6304.79	274.80	1961	1961	1962	1963	140.07
	633.43	304.44	2175	2175	2175	2176	139.97
	6382.99	353.00	2525	2526	2526	2526	139.77
	6402.25	372.26	2662	2664	2664	2663	139.78
	6506.53	476.54	3422	3424	3421	3421	139.22
	6532.88	502.89	3615	3618	3615	3616	139.04
ul	6553.7		3770	3771	3764	3762	(139.0)
ul'	6573.2		3908	3912	3910	3907	(138.9)
	6598.95	568.96	4097	4098	4098	4097	138.85
	6678.28	648.29	4680	4682	4679	4680	138.50
	6717.04	687.05	4966	4968	4967	4966	138.31
			5241	5242	5241	5240	
			6171	6175	6176	6173	
	6929.47	899.48	6549	6551	6553	6551	137.29
	7032.41	1007.42	7332	7332	7332	7332	136.72

MEASUREMENTS OF PLATE 111

TABLE 16

	λ (Å)	Δλ (Å)	d_1 (μ)	d_2 (μ)	Disp. (Å/mm)
	4271.77	1580.72	11023	11024	143.39
	4307.91	1544.58	10774	10774	143.36
	4325.77	1526.72	10654	10652	143.31
u1	4334.7		10592	10592	(143.3)
	4375.93	1476.56	10307	10306	143.26
	4383.55	1468.94	10255	10254	143.38
u2	4853.8		7023	7023	(142.2)
u2'	4867.2		6929	6929	(142.2)
	4890.77	961.72	6773	6762	142.10
	4919.85	932.64	6566	6564	142.06
	4957.56	895.53	6308	6307	141.97
			5748	5748	
			5454	5453	
	5852.49	0	0	0	
	6266.49	414.00	3046	3048	135.89
	6304.79	452.30	3333	3337	135.64
	6334.43	481.94	3560	3558	135.43
	6382.99	530.50	3930	3930	135.02
	6402.35	549.76	4075	4075	134.94
	6506.53	654.04	4878	4876	134.13
	6532.88	680.39	5082	5081	133.92
u3	6551.7		5231	5230	(133.7)
u3'	6571.2		5381	5380	(133.6)

MEASUREMENTS OF PLATE 122

TABLE 17

	λ (Å)	Δλ (Å)	d_1 (μ)	d_2 (μ)	d_3 (μ)	d_4 (μ)	d_5 (μ)	d_6 (μ)	d_7 (μ)	Disp. (Å/mm)
	4217.55	1439.11						9991	9992	144.03
	4250.79	1405.87	9763	9758				9757	9762	144.05
	4260.48	1396.18	9694	9694				9691	9692	144.05
	4271.77	1384.89	9615	9615	9613	9616	9614	9615	9616	144.04
	4307.91	1348.75	9368	9368				9366	9368	144.01
	4325.77	1330.89	9244	9243	9238	9240	9240	9244	9242	144.01
u1	4335.9		9169	9171	9170	9170	9170	9174	9173	(144.0)
u1'	4346.7		9088	9087	9097	9107	9108	9097	9094	(144.0)
	4375.93	1280.73	8897	8896				8896	8894	143.98
	4383.55	1273.11	8844	8844	8845	8844	8844	8847	8848	143.93
	4404.75	1251.91	8695	8696				8702	8701	143.97
	4415.12	1241.54	8633	8636					8633	143.83
	4427.31	1229.35	8538	8540				8544	8540	143.99
			8310	8313				8316	8310	
			8167	8168				8166	8168	
u2	4855.2	801.50	5598	5598	5594	5601	5618	5595	5600	(143.2)
u2'	4870.3	786.34	5483	5482	5499	5506	5515	5493	5497	(143.2)
			5158		5156	5157	5155	5154	5154	
	4957.56	699.10	4901	4903	4896	4898	4897	4897	4898	142.74
			4340	4341				4340	4340	
			3798	3798				3799	3796	
	5167.49	489.17	3436	3437	3439	3437	3436	3435	3436	142.34
	5227.19	429.47	3027	3029	3026	3028	3029	3027	3025	141.87
	5269.54	387.12	2729	2726	2725		2729	2727	2727	141.97
	5330.78	325.88	2308	2309	2311	2312	2310	2310	2311	141.07
	5341.09	315.57	2224	2226	2225	2225	2224	2227	2229	141.79
	5371.49	285.17	2013	2016	2010	2015	2014	2013	2014	141.62
	5400.56	256.10	1806	1809	1808	1803	1805	1811	1810	141.69
	5656.66	0	0	0	0	0	0	0	0	
	5689.82	33.16	237	239	238	240	239	238	238	139.09
	5719.22	62.56	447	447	445	445	449	445	447	140.14
	5748.30	91.64	657	659	659	655	659	659	658	139.27
	5764.42	107.76	771	773	774	774	773	773	773	139.51
	5804.45	147.79	1061	1061	1063	1061	1064	1060	1062	139.20
	5820.15	163.49	1176	1176	1175	1176	1177	1175	1176	139.04
	5852.49	195.83	1404	1409	1412	1411	1409	1406	1407	139.06
	5881.89	225.23	1618	1618	1619	1620	1624	1622	1625	138.96
	5944.83	288.17	2074	2072	2078	2077	2078	2080	2085	138.79
	5975.53	318.87	2299	2299	2302	2300	2304	2306	2302	138.68
	6029.99	373.33	2700	2696	2699	2698	2702	2703	2702	138.34
	6074.34	417.68	3032	3030	3032	3030	3032	3031	3033	137.85
	6096.16	439.50	3193	3192	3193	3197	3200	3194	3199	137.60
	6143.06	486.40	3548	3549	3548	3547	3554	3548	3554	137.08
	6163.59	506.93	3698	3699	3703	3700	3704	3702	3706	137.00

(continued)

MEASUREMENTS OF PLATE 123

TABLE 18

	λ	$\Delta\lambda$	d_1	d_2	d_3	d_4	d_5	d_6	d_7	Disp.
	6217.28	560.62	4094	4096	4102	4099	4100	4099	4103	136.82
	6266.49	609.83	4463	4463	4465	4466	4468	4462	4468	136.62
	6304.79	648.13	4743	4747	4752	4752	4753	4749	4754	136.49
	6334.43	677.77	4971	4971	4974	4973	4975	4976	4969	136.33
	6382.99	726.33	5337	5337	5334	5343	5343	5341	5345	136.01
	6402.25	745.59	5488	5484	5487	5486	5486	5482	5489	135.94
	6506.53	849.87	6283	6280	6288	6281	6286	6285	6292	135.25
	6532.18	876.22	6487	6484	6489	6489	6498	6490	6493	135.06
u3	6553.9		6653	6654	6657	6657	6659	6660	6650	(134.8)
u3'	6571.9			6806	6791	6785	6788	6791	6797	(134.8)
	6598.95	942.29	6996	6996	7003	7001	7002	7002	6992	134.60

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