

A SEARCH FOR RARE EARTH ELEMENTS (BOTH LANTHANIDES
AND ACTINIDES) IN THE PECULIAR A-STAR BETA
CORONAE BOREALIS

By

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II

Bachelor of Arts

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1969

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1974

NOV 25 1974

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ACKNOWLEDGEMENTS

The author would like to take this time to express his sincere gratitude to Dr. Leon W. Schroeder, my thesis adviser, for suggesting this topic, and providing invaluable guidance in the preparation and writing of this thesis.

I wish also to thank Dr. John C. Evans of Kansas State University who assisted Dr. Schroeder in my endeavor. It was through their efforts that I was able to make intensity tracings at Kitt Peak National Observatory Headquarters in Tucson, Arizona in May of 1972.

Finally, I would like to express deep appreciation and affection to my wife, Teresa, who has contributed a great amount of encouragement and understanding while preparing this thesis from its initial conception.

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CHAPTER I

INTRODUCTION

Although their spectral peculiarities have been known for almost fifty years, the peculiar A stars still present one of the most interesting problems in modern astrophysics. Following the discovery of Babcock (1947) that the sharp-lined, peculiar A stars have large magnetic fields, several analyses have been made of the spectra of individual stars. In each case the authors agree that the stars have abnormal compositions. This phenomenon is supposed to be a purely surface phenomenon which has been brought about by nuclear reactions between particles accelerated in magnetic fields (Burbidge and Burbidge, 1955). However, recent studies of several A stars, along with the discovery of new kinds of spectroscopic peculiarities, have resulted in little advance in our understanding of the phenomena involved. It seems that each new discovery has done more to eliminate particular nuclear theories than to confirm them. This was stated in part by W. L. Sargent (1964) in his paper.

It is not the purpose of this thesis to pursue the current theories involving the production of the rare earth elements, for we will merely touch upon them briefly. Our attention will focus on the matter at hand, that is, to present an extended identification list of rare earth elements for the peculiar A star Beta Coronae Borealis. This

star is peculiar because it has more enhanced lines of europium chromium, and strontium than so-called "normal" stars.

Intensity tracings were made by the author during May, 1972 from spectrograms of Beta Coronae Borealis. The spectrograms used in this study were made by Dr. Leon Schroeder and Dr. Ronald Oines both of Oklahoma State University and Dr. John Evans of Kansas State University in June of 1971. From these intensity tracings an extensive search for rare earth elements (both Lanthinides and Actinides) has been conducted for the wavelength interval $\lambda\lambda 3408-6959$. Beta Coronae Borealis (1970: $\alpha=15^{\text{h}}26^{\text{m}}35^{\text{s}}$, $\delta=+29^{\circ}12'$, photographic apparent magnitude +3.93) has been classified in the Henry Draper Catalog as an F0p and by Sargent and Searle in 1962 (Paschen Type) as an A5p. This peculiar A star has been studied previously by several investigators.

The Sr-Cr-Eu star Beta Coronae Borealis (HD 137909) has one of the greatest known rare earth abundances (Hack 1958; Hardorp and Shore 1971; Adelman 1973; Shore and Hardorp 1974). It is the brightest example of a sharp-lined cool magnetic Ap star with an apparent rotational velocity of ≤ 3 km/sec (Adelman and Shore 1973; Preston 1971). Its lines are broadened somewhat by a magnetic field of 6 kilogauss (Preston 1969). Spectroscopic studies reveal that it is not a spectrum variable; however it is both a magnetic and light variable (Wolff and Morrison 1971). It is indeed a spectroscopic binary with a period of 10.5 years (Neubauer 1944).

In 1945 W. A. Hiltner (University of Michigan) prepared one of the more definitive line identification lists which covered the spectral region $\lambda\lambda 3980-4638$. This was done by a short-screw measuring engine directly on the spectrogram. An abundance determination was made by

Hack in 1958. And, in 1965, a curve of growth was made by Fowler, et al. J. Gruber (1972) extended this identification list to include the spectral region $\lambda\lambda 3613-4863$. Such a finding list is a necessary precursor to a fine analysis of the spectrum with our ultimate goal being an abundance determination of the rare earth and other elements present in this star.

It is therefore the purpose of this paper to substantiate previous findings as well as to contribute what the author considers vital information to the data already known about this peculiar A star.

CHAPTER II

OBSERVATIONAL MATERIAL

The Spectrograms

The spectrograms used in this study were made at the coudé focus of the 84-inch telescope at Kitt Peak National Observatory in June of 1971 by Drs. Leon Schroeder and Ronald Oines both of Oklahoma State University, and Dr. John Evans of Kansas State University. Kitt Peak Observatory is operated by the Association of Universities for Research in Astronomy, Inc. (AURA), under contract with the National Science Foundation. Table I contains data on the spectrograms and on the spectrograph and cameras used to record them.

The spectrograms themselves are between 975\AA and 1600\AA wide and were exposed on 28 inches of photographic plate, each of which was divided into two ten-inch segments and one eight-inch segment. The first 28 inch plate (D2837) contains the absorption spectrum from about 3400\AA to about 5000\AA . The second plate (D2829) contains the absorption spectrum from about 3600\AA to about 4950\AA . Finally, the last plate (D2836) contains the absorption spectrum from about 4525\AA to about 6959\AA .

TABLE I
DATA FOR 84-INCH COUDÉ SPECTROGRAPH

Plate D2829:

Slit Width: 0.075 millimeter

Decker Dimensions: Decker 9

Stellar length: 1.16 millimeter or 3.6 seconds

Comparison length (inner): 1.78 millimeter

Comparison length (outer): 5.29 millimeter

Grating "C":

Bausch and Lomb No. 33-53-36-35, ruled with two diamonds

Ruled area: 204 x 254 millimeter

Grooves per millimeter: 600

Blaze: 8000 \AA (1st order)

Ghost intensity: 0.06% of parent line

CAMERA: 6

Grating tilt: 7935

Plate position: 46.0

Central wavelength: 4400 \AA

Focus: 60.60

Tilt: 4.15

Emulsion: II a-0

Exposure meter count: 15988

Calibration: Sensitometer,

5-74 filter; Neutral density

factor x 100; Exposure time

21 minutes.

Developer: D-19 for 4 minutes

f-ratio: f/16

Focal length: 143.8 inches

Demagnification from slit to
plate: 1.88

Dispersion (2nd order blue):
2.2 $\text{\AA}/\text{mm}$

Plate width: 27/32 inches

Plate length: 28 inches

Starlight exposure time: 39
minutes

Iron arc comparison exposure
time: 10 sec (no filter)

Temperature in spectrograph
room: 61 $^{\circ}\text{F}$

POSITION OF STAR:

$\alpha(1970) = 15^{\text{h}}26^{\text{m}}35^{\text{s}}$

$\delta(1970) = 29^{\circ}12'$

OBSERVING CONDITIONS:

Seeing: 1

Trans: 4

Photographic apparent magnitude: +3.93

TABLE I (Continued)

Plate D2836:Slit Width: 0.075 millimeterDecker Dimensions: Decker 9

Stellar length: 1.16 millimeter or 3.6 seconds

Comparison length (inner): 1.78 millimeter

Comparison length (outer): 5.29

Grating "C":

Bausch and Lomb No. 33-53-36-35, ruled with two diamonds

Ruled area: 204 x 254 millimeter

Grooves per millimeter: 600

Blaze: 8000Å (1st order)

Ghost intensity: 0.06% of parent line

CAMERA:

Grating tilt: 8056

Plate position: 46.0 (low)

Central wavelength: 5400Å

Focus: 60.60

Tilt: 4.15

Emulsion: II a-F

Exposure meter count: 50981

Calibration: Sensitometer,

4-102 filter; Neutral density

factor x 100; Exposure time

34 minutes

Developer: D-19 for 4 minutes

f-ratio: f/16

Focal length: 143.8 inches

Demagnification from slit to
plate: 1.88Dispersion (1st order blue):
4.4 Å/mm

Plate width: 27/32 inches

Plate length: 28 inches

Starlight exposure time: 2^h03^mNeon arc comparison exposure
time: 120 secondsIron arc comparison exposure
time: 10 seconds (no filter)Temperature in spectrograph
room: 61°FPOSITION OF STAR: $\alpha(1970) = 15^{\text{h}}26^{\text{m}}35^{\text{s}}$ $\delta(1970) = 29^{\circ}12'$ OBSERVING CONDITIONS:

Seeing: 0.8-1

Trans: 2-3

Photographic apparent magnitude: +3.93

TABLE I (Concluded)

Plate D2837:Slit Width: 0.075 millimeterDecker Dimensions: Decker 9

Stellar length: 1.16 millimeter or 3.6 seconds

Comparison length (inner): 1.78 millimeter

Comparison length (outer): 5.29 millimeter

Grating "C":

Bausch and Lomb No. 33-53-36-35, ruled with two diamonds

Ruled area: 204 x 254 millimeter

Grooves per millimeter: 600

Blaze: 8000Å (1st order)

Ghost intensity: 0.06% of parent line

CAMERA: 6

Grating tilt: 7949

Plate position: 46.0 (low)

Central wavelength: 4200Å

Focus: 60.60

Tilt: 4.15

Emulsion: II a-0

Exposure meter count: 18574

Calibration: Sensitometer,

5-74 filter; Neutral density

factor x 100; Exposure time

21 minutes

Developer: D-19 for 4 minutes

f-ratio: f/16

Focal length: 143.8 inches

Demagnification from slit to

plate: 1.88

Dispersion (2nd order blue):

2.2 Å/mm

Plate width: 27/32 inches

Plate length: 28 inches

Starlight exposure time:

42 minutes

Iron arc comparison exposure

time: 10 seconds (no filter)

Temperature in spectrograph

room: 61°F

POSITION OF STAR: $\alpha(1970) = 15^{\text{h}}26^{\text{m}}35^{\text{s}}$ $\delta(1970) = 29^{\circ}12'$ OBSERVING CONDITIONS:

Seeing: 0.8-1

Trans: 2-3

Photographic apparent magnitude: +3.93

The Intensity Tracings

Nine intensity tracings covering the wavelength range $\lambda\lambda 3400-6959$ were made by the author in May of 1972 with the Hilger-Watts Direct Intensity Microphotometer (Model L-470) at Kitt Peak National Observatory Headquarters in Tucson, Arizona at a carriage speed of 0.50 mm/minute resulting in a plate-to-chart magnification of 102.5/1. Table II below gives the pertinent data for the settings on the microphotometer when the tracings were made.

TABLE II
DATA FOR MICROPHOTOMETER (D2829,D2836,D2837)

Reference Current:	0.60 milliamps
Slit Rotation Setting:	28.5
Slit Length Setting:	2.75
Slit Width Setting:	12
Brown Recorder Gear Ratio:	80/40

A portion of one of the direct intensity tracings is illustrated in Figure 1.

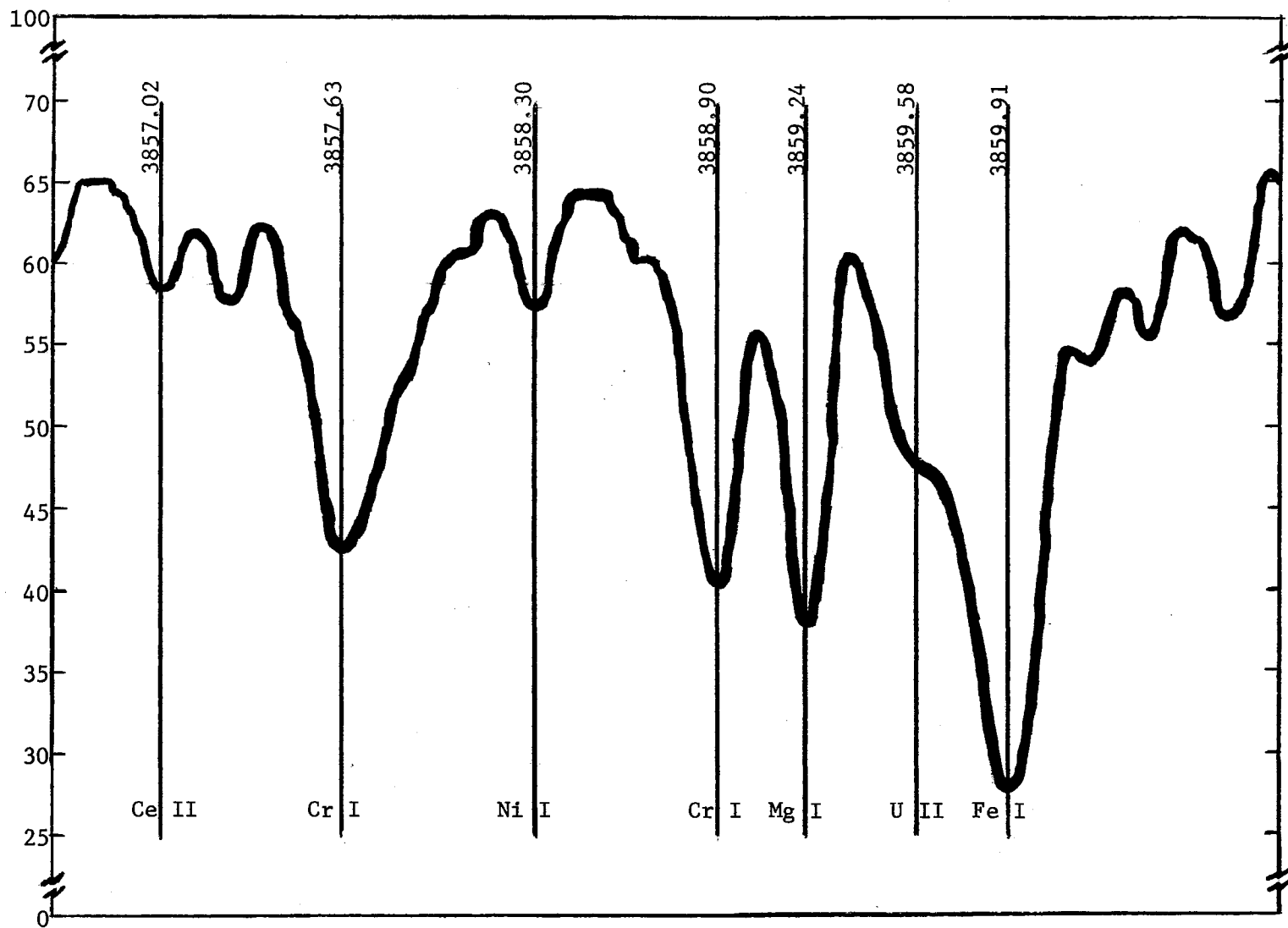


Figure 1. Scale Drawing of Microphotometer Tracing

CHAPTER III

IDENTIFICATION OF SPECTRAL LINES

Method of Line Identification

Now that all of this data is at our disposal, the question arises of how do we actually identify any elements present in the atmosphere of this peculiar A star. The usual techniques of line measurement on spectrograms using a measuring engine were not employed. The identifications were made directly from the intensity tracings.

Initially one looks for the strong hydrogen lines (common to all A stars) with their broad profiles. Then one proceeds to identify the other strong features. One important point should be noted at this time; in order to make the identifications it was assumed that there is nearly a linear relationship between the distance along the abscissa of the tracing and the wavelength, as is expected from grating spectra. Using this assumption for two strong features on the tracings that have been properly identified, one can determine this relationship, or, as it is more commonly called, the "dispersion." The dispersion is usually expressed in angstroms per inch. It is then very easy to measure the wavelengths of all the lines between these two strong features and tentatively identify them. Dispersion curves for all the intensity tracings used are shown in Figures 2,3,4,5,6,7, and 8.

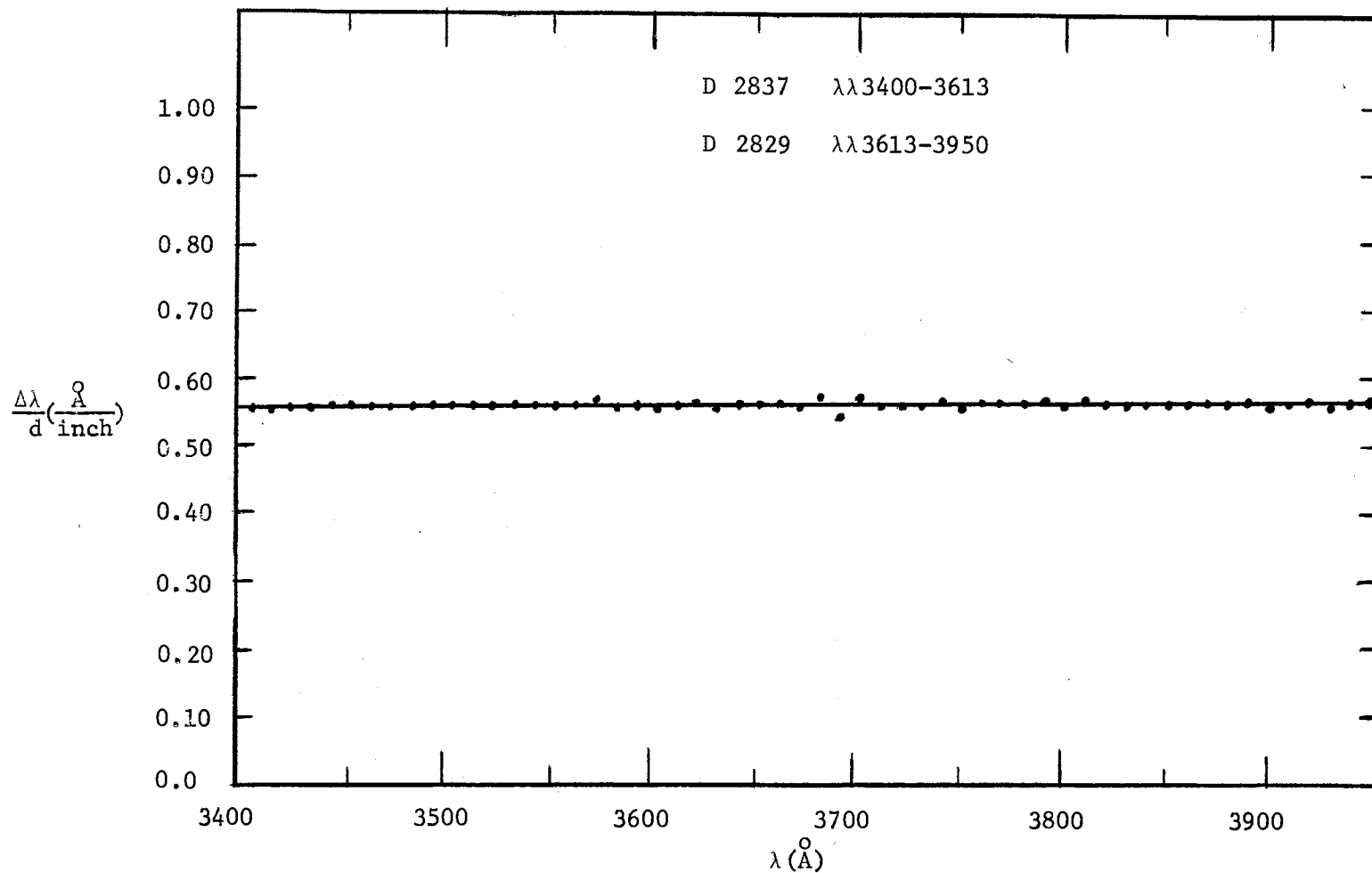


Figure 2. Dispersion Curve for the Wavelength Region $\lambda\lambda 3400-3950$

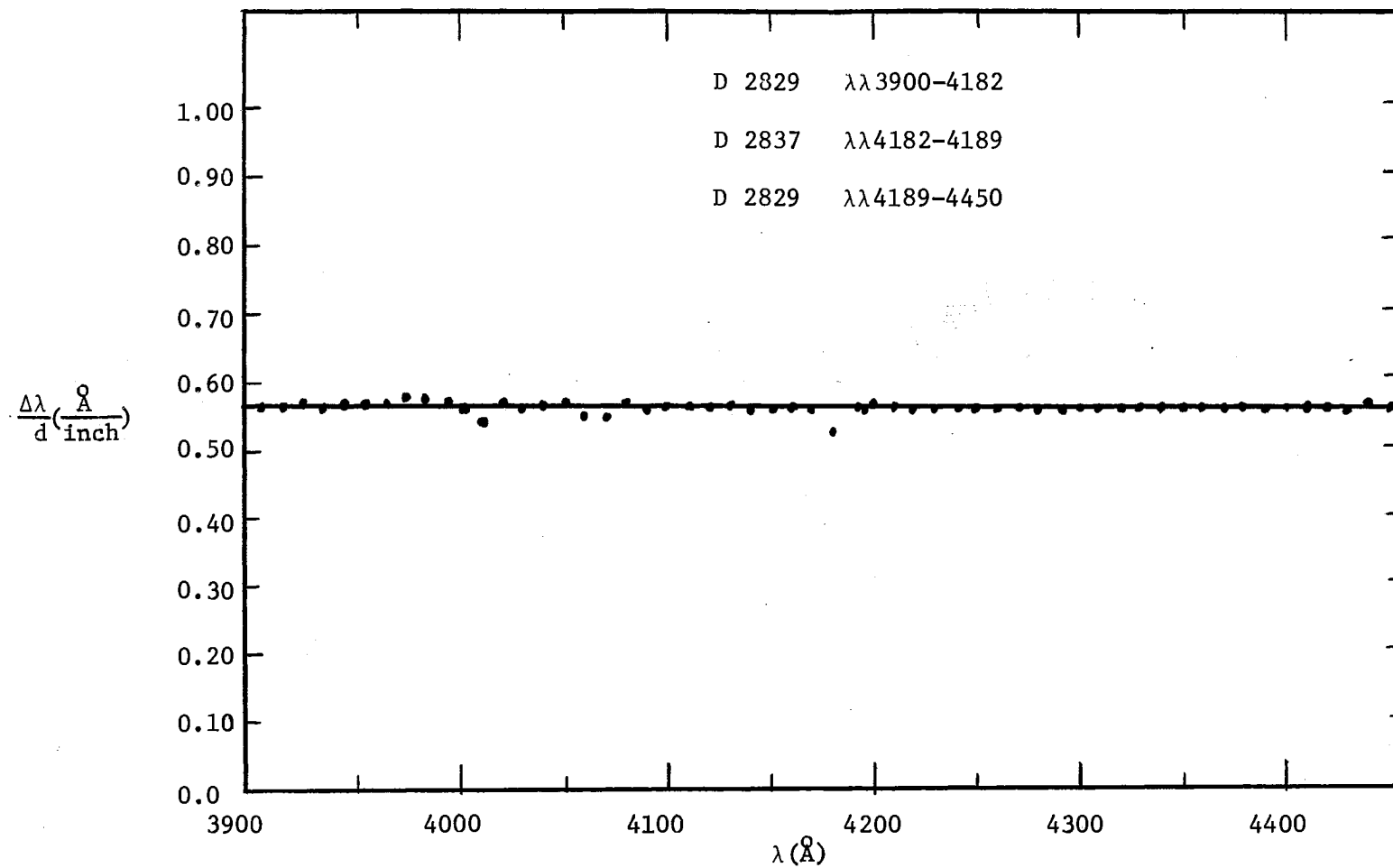


Figure 3. Dispersion Curve for the Wavelength Region λλ3900-4450

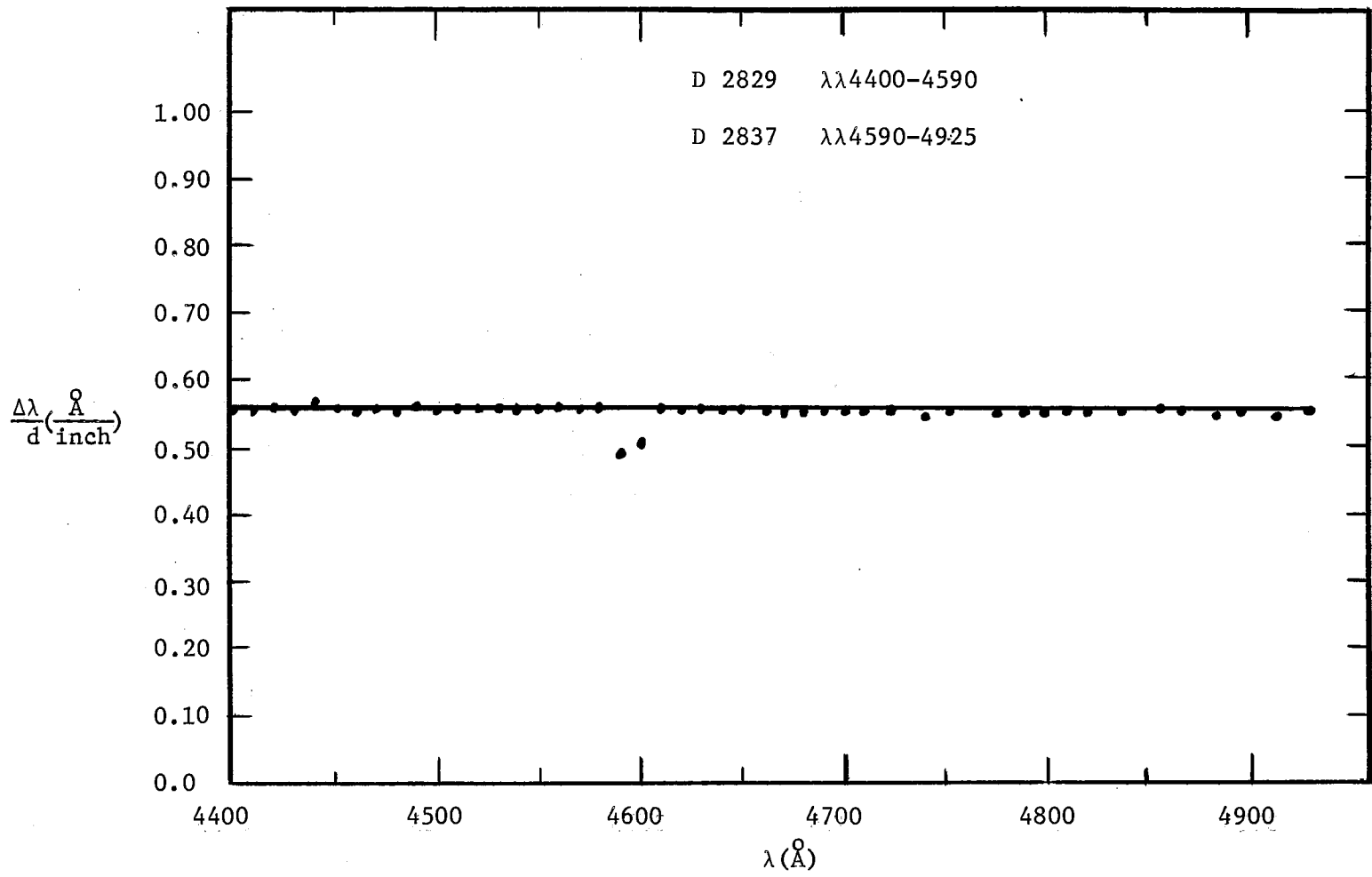


Figure 4. Dispersion Curve for the Wavelength Region λλ4400-4940

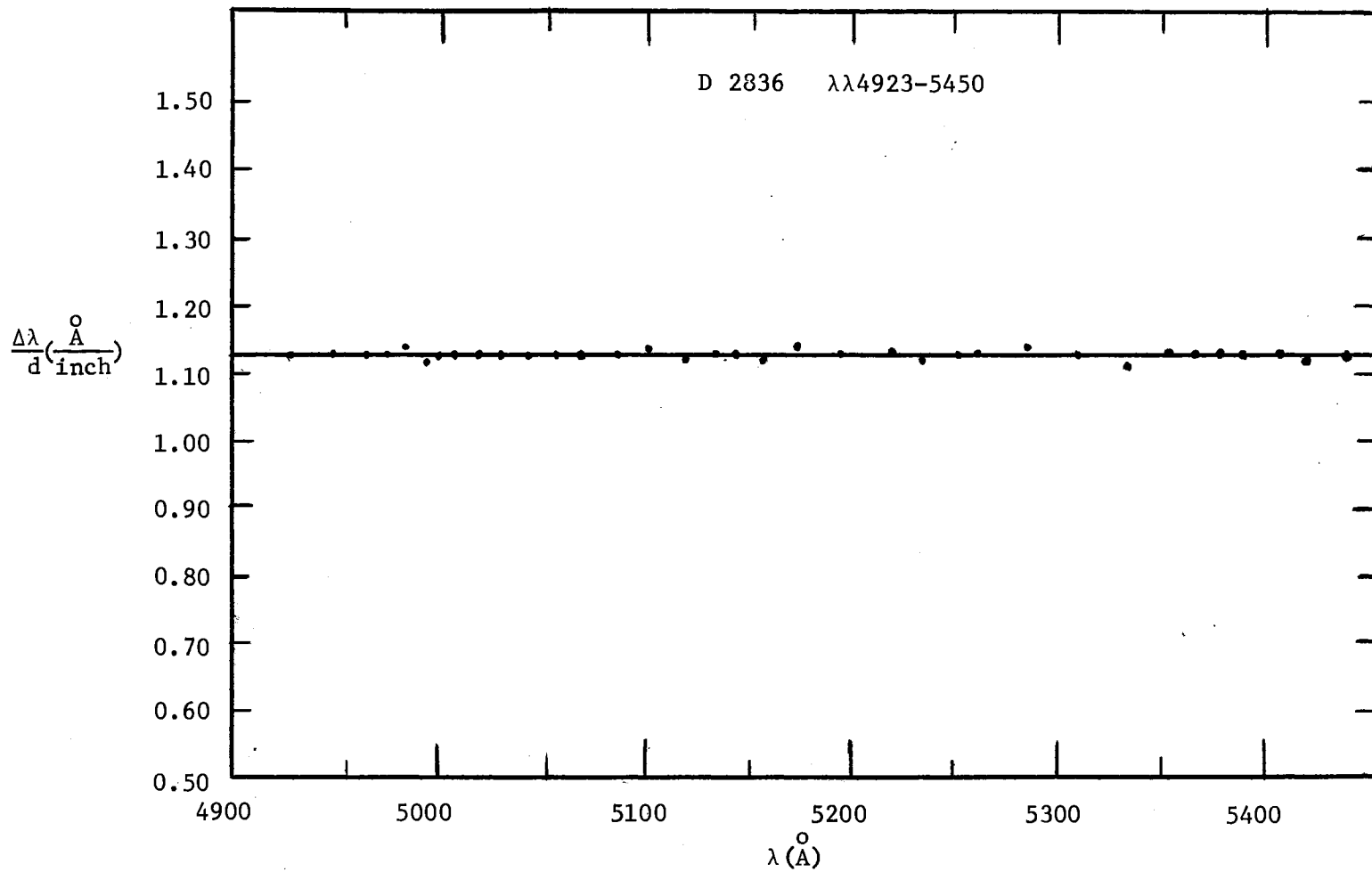


Figure 5. Dispersion Curve for the Wavelength Region $\lambda\lambda 4900-5450$

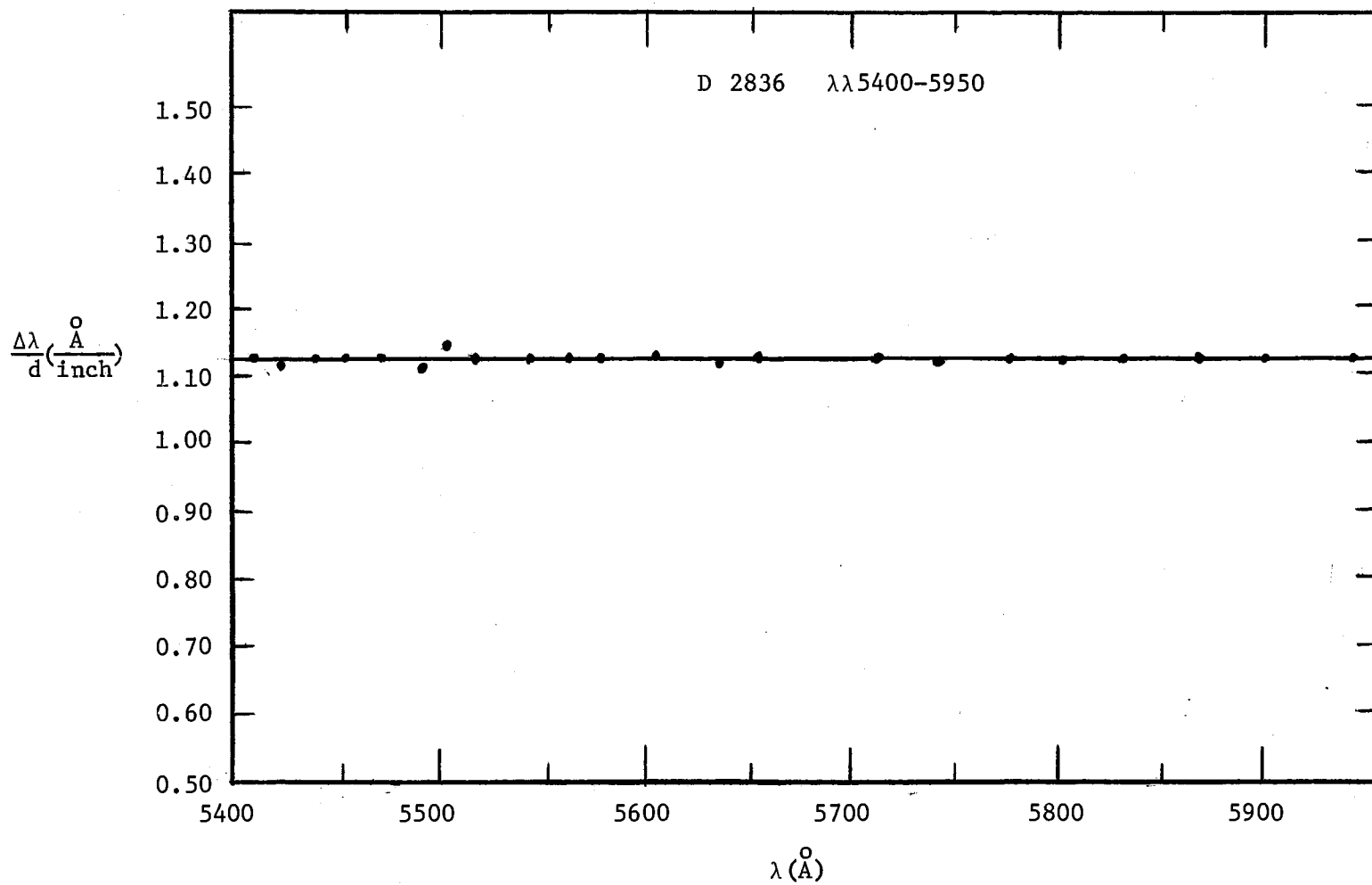


Figure 6. Dispersion Curve for the Wavelength Region $\lambda\lambda 5400-5950$

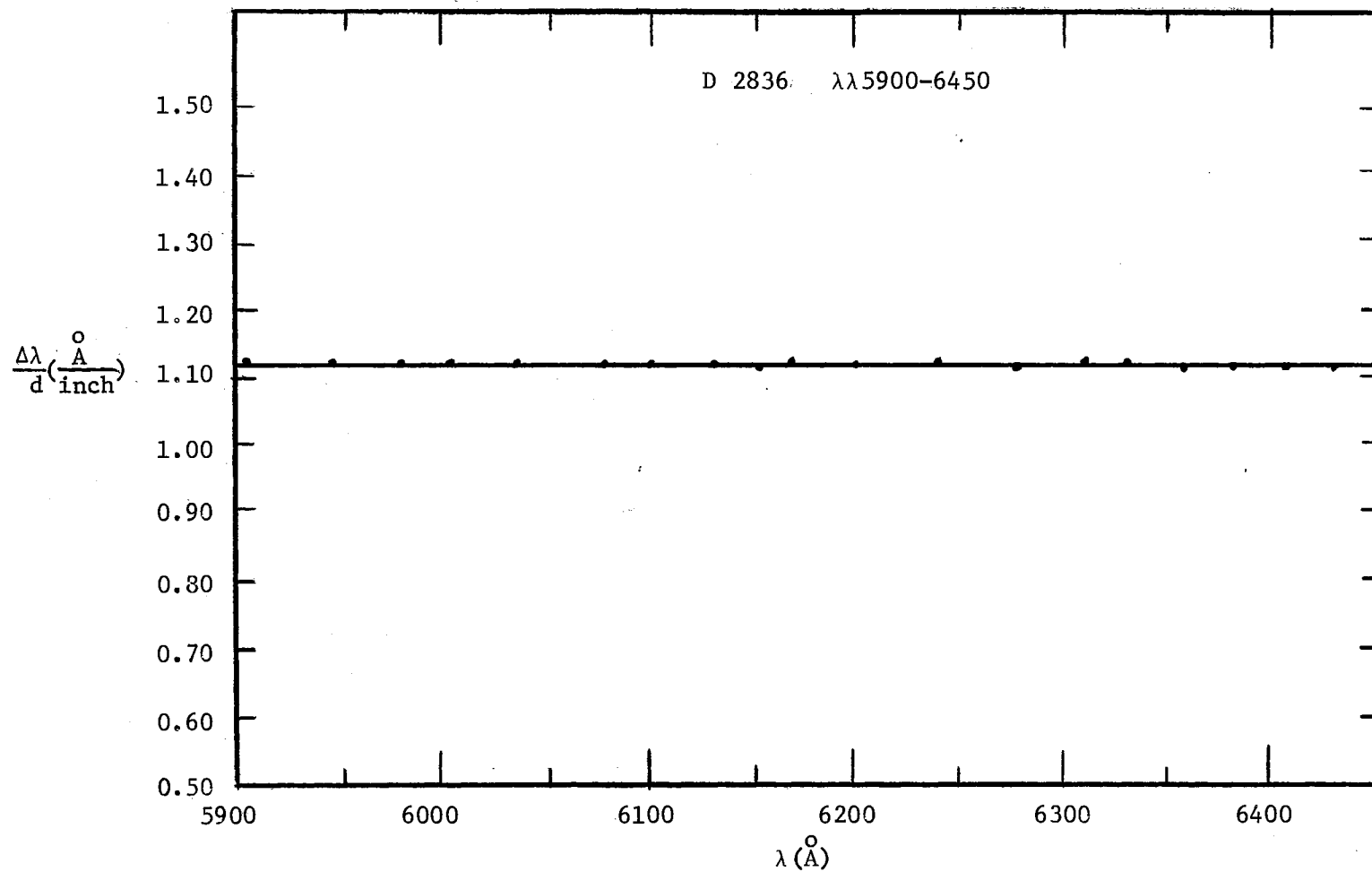


Figure 7. Dispersion Curve for the Wavelength Region λλ5900-6450

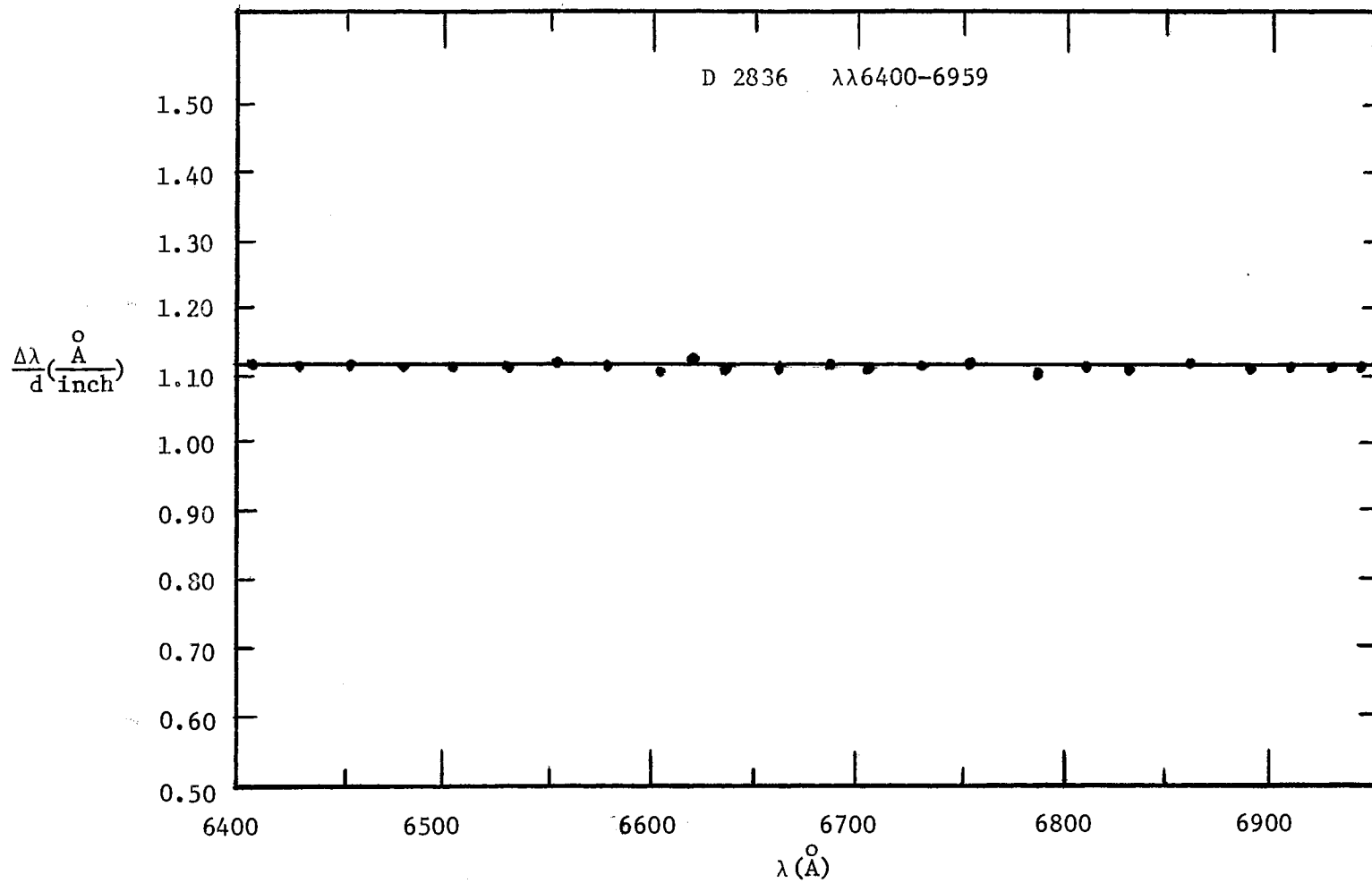


Figure 8. Dispersion Curve for the Wavelength Region $\lambda\lambda 6400-6959$

The strong absorption lines were confirmed with the aid of the density tracings of the peculiar A star γ Equulei. The tracings were obtained from Dr. John Evans at Kansas State University. Along with these tracings used was an identification list prepared by W. P. Bidelman (1972) for γ Equulei, a similar peculiar A star. It was these tracings that proved to be a valuable source for identification of elements present in β Coronae Borealis.

Another identification list used was prepared by W. A. Hiltner in 1945 covering the spectral region $\lambda\lambda 3987-4642$. These identifications were made directly from the spectrograms.

The main sources used for identifications were National Bureau of Standards Monograph No. 32 (Parts I and II) by W. F. Meggers, C. H. Corliss and B. F. Scribner (1961) and A Multiplet Table of Astrophysical Interest (revised edition) by Charlotte E. Moore (1959).

In the work done here all the lines from the tracings show the effects of the radial velocity of the star. However, by choosing two nearby strong features and using their laboratory wavelengths, the effects of radial velocity are essentially constant over that particular spectral region. Therefore the resulting line determinations are also "corrected" for radial velocity.

The absorption lines identified for the rare earths and other elements of particular interest for Beta Coronae Borealis, along with their laboratory wavelengths, are presented in Tables III, IV, V, and VI.

The wavelengths measured were very close to those listed in the Revised Multiplet Table (RMT) and the National Bureau of Standards Monograph.

Explanation of Tables

The first column gives the wavelength in international angstrom units. The second column is the multiplet number of the element if it has been identified in the Revised Multiplet Table. The third column contains the number of measurements determined for that particular wavelength. The designation 1 is used where only one spectrogram was used; 2 is used where an overlap occurred on two spectrograms, and finally the number 3 is used where three spectrograms overlap. The fourth column contains the source used in the identification. The designation R is used for the Revised Multiplet Table; N is used for the National Bureau of Standards Monograph No. 32. The designation M is employed when the MIT Wavelength Tables were used. The designation JO is used for the Optical Society of America, Journal; and JR is used for the National Bureau of Standards Journal of Research and SA for Spectrochimica Acta. The designation JENER is used for the Joint Establishment for Nuclear Energy Research and finally, A for Adelman (1974). The final column contains comments.

The comments are broken down into four basic categories. The designation U is used when the line has been associated with an unblended feature on the intensity tracing. The designation B is employed when the identification of two lines has been made. The feature on the intensity tracing suggests the presence of two lines. The designation CB is used for a complex blend. A complex blend on the tracing is one that suggests the presence of three or more absorption lines. Finally, the designation BB refers to a badly blended feature. The elements identified which have this comment are only probable identifications. That is, there is only a mere suggestion of

the presence of this particular line.

The elements presented in Tables III, IV, V, and VI are in the order of increasing atomic number and increasing state of ionization. The designation of the element is given by its internationally accepted chemical symbol. The element symbol is then followed by its degree of ionization; the neutral ion is given by the character "I", the singly ionized ion is given by the character "II", and the doubly ionized ion is characterized by the character "III." If the element has no designation following its symbol then its degree of ionization has not, as yet, been determined.

In Table III the elements listed are those of the rare earths in the Lanthanide Series. Table IV contains the rare earth elements in the Actinide Series. Table V has other elements that are of astrophysical interest in that not all of them are common to A-stars. Finally, in Table VI the doubly ionized rare earths are listed.

TABLE III
IDENTIFICATION OF LANTHANIDES

λ	Multiplet	Number of Measurements	Source	Comments
CeI				
3666.02		2	N	U
4365.95		2	N	B
4447.69		2	N	B
4674.49		3	N	U
4775.08		3	N	U
4784.78		3	N	U
4843.03		3	N	CB
49.91		3	N	U
52.62		3	N	B
53.61		3	N	B
59.48		3	N	B
97.08		3	N	B
4898.21		3	N	U
4908.12		3	N	U
30.54		3	N	CB
50.52		3	N	B
54.04		3	N	U
55.97		3	N	B
65.18		3	N	B
70.67		3	N	CB
4971.94		3	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeI (Continued)				
4974.10		3	N	U
87.54		3	N	B
88.69		3	N	U
4998.13		3	N	B
5009.09		1	N	U
13.76		1	N	B
33.81		1	N	B
39.75		1	N	U
65.88		1	N	U
74.71		1	N	U
80.48		1	N	U
5091.75		1	N	U
5111.60		1	N	B
15.22		1	N	U
22.39		1	N	B
34.47		1	N	B
35.32		1	N	B
40.50		1	N	B
5181.94		1	N	B
5230.84		1	N	U
5329.50		1	N	B
5335.71		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeI (Continued)				
5355.62		1	N	CB
59.18		1	N	B
59.30		1	N	B
86.35		1	N	B
5399.57		1	N	U
5414.09		1	N	U
49.22		1	N	U
53.95		1	N	U
60.09		1	N	CB
5468.37		1	N	B
5522.46		1	N	U
5559.22		1	N	U
5601.30		1	N	U
10.92		1	N	B
33.09		1	N	U
38.19		1	N	B
50.60		1	N	B
55.13		1	N	B
75.10		1	N	CB
5695.84		1	N	U
5702.39		1	N	U
5775.00		1	N	U

TABLE III (Continued)

λ	Multiplet	Measurements	Source	Comments
CeI (Continued)				
5793.78		1	N	U
5812.93		1	N	B
38.16		1	N	B
5893.19		1	N	B
5909.86		1	N	B
10.13		1	N	B
26.30		1	N	B
28.34		1	N	B
32.16		1	N	B
37.72		1	N	CB
42.66		1	N	CB
5944.88		1	N	B
6000.18		1	N	U
16.57		1	N	CB
6024.19		1	N	B
6118.89		1	N	B
6306.63		1	N	B
6335.37		1	N	B
6490.99		1	N	B
6704.38		1	N	B
6775.59		1	N	U
6826.43		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeI (Continued)				
6829.37		1	N	CB
47.25		1	N	B
6894.57		1	N	CB
6939.44		1	N	B
CeII				
3422.71	144	1	R	U
26.21	44	1	R	U
39.83	197	1	R	B
3475.68		1	N	U
3501.45	67	1	R	U
02.89		1	N	B
06.25		1	N	U
19.08		1	N	B
20.52	55	1	R	U
31.59		1	N	B
34.05	44	1	R	U
34.44		1	N	U
46.19	131	1	R	U
46.66		1	N	U
60.80	51	1	R	B
69.32		1	N	B
3577.46	51	1	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
3580.56		1	N	B
98.20	116	1	R	U
3599.97	219	1	R	B
3607.63	178	1	R	U
09.69	179	1	R	U
10.91		1	N	CB
11.34		1	N	B
13.70	110	2	R	B
18.58		2	N	U
22.44		2	N	B
24.18		2	N	B
28.25		2	N	U
31.19	88	2	R	CB
40.69		2	N	U
44.55		2	M	CB
46.97	66	2	R	U
49.73		2	N	U
54.97		2	N	U
56.76		2	M	B
61.73		2	N	B
66.35		2	M	B
3671.94		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
3679.42		2	N	U
80.08		2	N	U
94.91	63	2	R	B
98.36		2	N	BB
3698.66		2	N	B
3704.98		2	N	B
25.68		2	N	U
26.46		2	M	BB
28.18		2	N	BB
28.99		2	N	U
37.74		2	N	B
55.43	148	2	R	B
72.65		2	N	U
81.62	143	2	R	B
82.52	142	2	R	B
92.33	129	2	R	U
94.68		2	N	B
3795.26	50	2	R	U
3801.53	172	2	R	U
03.10	37	2	R	B
03.84		2	N	B
3808.39	Unclassified	2	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
3836.11	60	2	R	B
37.21	112	2	R	U
41.72		2	N	B
54.19	62	2	R	BB
57.24	127	2	R	U
68.14		2	N	BB
70.87		2	N	U
79.07		2	N	B
79.61		2	N	U
82.45		2	N	B
83.50		2	N	B
83.98		2	M	U
86.50		2	N	U
88.39		2	N	B
89.48		2	N	BB
94.32		2	N	U
3898.27		2	N	U
3901.30		2	N	U
03.93		2	N	B
07.45		2	N	B
09.05		2	N	U
3911.30		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
3912.42	60	2	R	B
13.99		2	N	B
16.14		2	N	BB
18.28		2	N	B
19.81	60	2	R	U
24.80		2	N	B
27.00		2	N	U
27.38	48	2	R	U
42.15	37	2	R	U
43.14	113	2	R	U
43.50		2	N	U
43.89	234	2	R	U
46.68	255	2	R	U
53.66	141	2	R	B
59.80		2	N	U
62.09		2	N	B
63.37		2	N	U
70.42		2	N	BB
70.64		2	N	U
77.77		2	N	U
80.90	194	2	R	U
3983.29		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
3989.44	240	2	R	U
90.69		2	N	U
92.39	134	2	R	U
92.91	226	2	R	U
93.82	12	2	R	B
97.72		2	N	B
3999.24	57	2	R	U
4000.80		2	N	B
02.81		2	N	B
03.77	188	2	R	U
05.64		2	N	U
07.59	221	2	R	B
09.06		2	N	B
11.56		2	N	U
14.90	157	2	R	U
15.88	256	2	R	U
19.90		2	N	B
28.41	47	2	R	B
31.34	108	2	R	B
38.25		2	N	U
42.14	252	2	R	B
4042.58	140	2	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
4045.21		2	N	B
53.51	36	2	R	B
54.99	82	2	R	B
62.22	34	2	R	B
70.09	Unclassified	2	R	B
72.92	109	2	R	U
73.48	4	2	R	U
75.85	206	2	R	BB
79.02		2	N	B
80.44	36	2	R	B
86.42		2	N	B
87.36		2	N	B
89.74		2	N	B
89.86		2	N	B
4093.96	160	2	R	U
4106.13	160	2	R	B
06.88	139	2	R	B
10.38	29	2	R	B
11.39	Unclassified	2	R	B
14.15		2	N	B
17.29	77	2	R	U
4117.59		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
4118.14	11	2	R	U
19.88	83	2	R	U
23.49	22	2	R	B
27.74		2	N	BB
31.10	112	2	R	B
35.44	188	2	R	U
35.89		2	N	U
37.65	2	2	R	U
42.40	10	2	R	U
48.16		2	N	B
51.97	2	2	R	B
55.53	29	2	R	B
59.03	246	2	R	U
60.11		2	N	B
60.18		2	N	B
61.18	22	2	R	B
65.61	10	2	R	B
66.65		2	N	U
67.80	29	2	R	B
69.77	161	2	R	B
69.88	173	2	R	B
4171.39		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
4181.08		2	N	B
85.33	124	2	R	B
86.60	1	2	R	U
87.32	86	2	R	BB
89.18		2	N	U
90.63	169	2	R	U
4193.28		2	N	B
4201.24		2	N	U
30.12		2	N	U
31.75	Unclassified	2	R	U
42.01		2	N	U
63.43	254	2	R	U
92.58		2	N	B
4292.77		2	N	B
4305.14		2	N	U
10.70	133	2	R	U
32.71		2	N	CB
39.32	34	2	R	B
42.49		2	N	B
44.92		2	M	U
61.66	157	2	R	U
4363.49		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
4367.00		2	N	U
72.40	169	2	R	B
73.22		2	N	U
81.78		2	N	U
94.78	259	2	R	U
4396.58		2	N	U
4405.47		2	N	CB
07.28	64	2	R	CB
18.78	2	2	R	U
19.30		2	N	U
27.07		2	N	B
39.24		2	N	U
53.16		2	N	U
64.17		2	N	U
64.69		2	N	U
88.81		2	N	B
92.95		2	N	U
94.24		2	N	U
4495.39	154	2	R	U
4510.92		2	N	U
15.86		2	N	U
4522.08		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
4536.89		3	N	U
39.07		3	N	U
50.34		3	N	B
63.38		3	N	B
72.28	1	3	R	BB
4593.93	6	3	R	B
4606.40		3	N	U
28.16	1	3	R	U
33.60		3	N	U
36.74		3	N	B
44.20		3	N	U
54.29	154	3	N	U
80.99		3	N	B
84.61	228	3	R	U
90.17		3	N	B
92.06		3	N	B
4694.88		3	N	B
4714.00	250	3	R	U
14.81	17	3	R	U
23.31		3	N	U
25.09		3	R	U
4737.28	Unclassified	3	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
4739.53	157	3	R	B
47.14	Unclassified	3	R	U
55.54		3	N	U
57.84	Unclassified	3	R	B
68.77		3	N	BB
4773.94	17	3	R	U
4858.72		3	N	U
74.01		3	N	B
82.46	Unclassified	3	R	U
4891.90		3	N	BB
4914.94		3	N	U
28.09		3	N	U
43.45		3	N	U
43.84		3	N	B
44.62		3	N	BB
61.49		3	N	B
71.48	Unclassified	3	R	U
77.23		3	N	BB
4986.42		3	N	B
5011.77		1	N	BB
22.87	16	1	R	B
5037.77		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
5044.01	16	1	R	U
75.30	14	1	R	U
5079.68	15	1	R	B
5117.17	23	1	R	CB
5181.45	15	1	R	U
5232.91		1	N	B
52.62		1	N	U
5274.24	15	1	R	U
5409.22	23	1	R	U
59.21		1	N	U
64.20		1	N	B
5468.37	24	1	R	CB
5512.09	24	1	R	B
5610.26	26	1	R	U
5613.70	32	1	R	U
5715.29		1	N	CB
68.89	32	1	R	B
5771.98		1	N	U
5817.78		1	N	B
5858.56		1	N	U
5975.87	30	1	R	U
5997.05		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeII (Continued)				
6033.58		1	N	U
34.20	30	1	R	B
35.49	30	1	R	U
43.39	30	1	R	U
6051.80		1	N	B
6108.74		1	N	U
6143.36		1	N	B
6232.45		1	N	U
6425.30		1	N	U
6606.86		1	N	U
Ce				
3459.39		1	M	B
93.94		1	M	B
3499.78		1	M	BB
3509.93		1	M	B
17.91		1	M	B
18.04		1	M	B
35.69		1	M	B
38.46		1	M	U
56.10		1	M	U
57.49		1	M	U
3583.97		1	M	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Ce (Continued)				
3594.10		1	M	U
3616.64		2	M	BB
23.76		2	M	BB
33.87		2	M	BB
35.78		2	M	B
41.73		2	M	B
43.45		2	M	BB
46.65		2	N	U
47.55		2	M	BB
48.10		2	M	B
51.31		2	M	BB
52.33		2	M	BB
54.09		2	M	BB
56.58		2	M	U
58.42		2	M	BB
58.77		2	M	BB
64.95		2	M	B
65.57		2	M	U
67.55		2	M	BB
70.49		2	N	U
75.37		2	M	BB
3675.52		2	M	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Ce (Continued)				
3680.63		2	M	U
84.24		2	M	U
85.01		2	M	B
3695.96		2	N	B
3703.37		2	M	BB
04.67		2	M	U
3751.45		2	N	BB
3844.84		2	M	U
47.81		2	M	U
60.18		2	M	U
60.40		2	M	U
66.82		2	M	U
76.37		2	M	U
3881.50		2	M	B
3905.30		2	M	U
37.81		2	N	U
64.18		2	N	U
3996.36		2	N	B
4027.69		2	N	B
4166.88		2	N	U
4203.15		2	M	U
4206.32		2	M	CB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Ce (Continued)				
4223.15		2	M	B
47.96		2	M	B
4266.08		2	M	B
4318.00		2	M	U
34.33		2	M	U
35.41		2	M	U
57.13		2	M	U
57.91		2	N	U
65.52		2	M	CB
66.11		2	M	U
71.86		2	M	CB
4397.68		2	M	U
4406.00		2	M	U
13.19		2	N	U
30.00		2	N	B
93.32		2	M	B
4499.75		2	M	U
4507.76		2	M	U
08.73		2	M	U
32.49		3	N	U
69.66		3	N	CB
4570.09		3	M	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Ce (Continued)				
4578.78		3	N	BB
79.28		3	N	B
4597.17		3	N	CB
4630.82		3	N	B
59.40		3	N	U
4665.28		3	N	U
4701.45		3	N	U
02.01		3	N	BB
04.01		3	M	BB
15.07		3	M	U
44.82		3	N	B
82.22		3	M	U
83.94		3	N	U
4793.16		3	N	U
4801.36		3	M	BB
4850.19		3	N	BB
4939.60		3	N	B
49.55		3	N	B
51.92		3	N	BB
55.39		3	M	BB
56.97		3	M	BB
4960.90		3	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Ce (Continued)				
4968.40		1	N	BB
4984.51		1	N	U
5002.80		1	N	B
25.13		1	N	B
30.64		1	N	U
77.82		1	N	U
5090.86		1	N	B
5118.87		1	N	U
5154.39		1	N	B
5337.70		1	N	B
5406.61		1	N	U
07.66		1	N	B
17.84		1	N	U
5457.89		1	N	B
5506.09		1	N	U
5582.57		1	M	U
5671.41		1	N	B
78.98		1	N	U
5685.86		1	N	B
5703.23		1	N	B
10.07		1	N	U
5716.50		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Ce (Continued)				
5724.14		1	N	BB
27.25		1	N	B
58.30		1	N	U
75.80		1	N	U
5799.80		1	N	U
5848.86		1	N	B
70.85		1	N	BB
5899.70		1	N	B
5907.49		1	N	B
29.50		1	N	BB
59.70		1	N	B
5981.20		1	N	B
6118.55		1	N	BB
6216.08		1	M	BB
6507.16		1	N	B
6686.59		1	N	U
6856.55		1	N	BB
85.51		1	N	BB
93.69		1	N	B
98.48		1	N	BB
6899.10		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
	PrI			
4660.92		3	N	U
4695.77		3	N	BB
4730.69		3	N	B
4744.16		3	N	U
4788.28		3	N	BB
4853.68		3	N	U
4896.14		3	N	U
4936.00		3	N	BB
4939.74		3	N	BB
4940.30		3	N	U
51.36		3	N	U
56.06		3	N	B
60.26		3	N	B
4970.92		3	N	B
5177.37		1	N	B
5195.48		1	N	B
5538.37		1	N	B
5879.07		1	N	U
5986.14		1	N	B
6118.02		1	N	BB
6218.08		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PrII				
3743.99		2	N	BB
3816.17	Unclassified	2	R	BB
3938.31		2	N	U
62.45	28	2	R	B
74.86		2	N	BB
3997.05	9	2	R	B
4004.71		2	N	B
06.70		2	N	B
10.64		2	N	B
16.75		2	N	U
38.47		2	N	BB
54.85	30	2	R	B
81.02	14	2	R	BB
4096.82	29	2	R	BB
4111.87		2	N	BB
29.15		2	N	B
4148.46		2	N	BB
4201.53		2	N	U
17.81		2	N	U
19.65		2	N	U
22.98	4	2	R	U
4253.53		2	N	

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PrII (Continued)				
4293.14		2	N	B
4293.58		2	N	B
4370.83		2	N	U
4396.12		2	N	U
4419.67		2	N	B
4520.78		2	N	BB
61.46	23	3	R	B
62.13		3	N	U
68.55	33	3	R	BB
4570.57		3	N	U
4628.75	1	3	R	U
43.51		3	N	BB
64.65		3	N	B
4678.17		3	N	B
4707.94		3	N	B
44.93	3	3	R	B
62.73	26	3	R	B
4765.22		3	N	U
4814.34		3	N	B
26.65	20	3	R	B
4848.55		3	N	U
4932.17		3	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PrII (Continued)				
4956.65		3	N	BB
4989.27		3	N	B
5015.54		1	N	BB
34.42	37	1	R	U
5075.68		1	N	B
5206.56	38	1	R	BB
16.85		1	N	U
5220.11	35	1	R	B
5513.58		1	N	BB
5731.87		1	N	B
5847.13		1	N	U
5981.21		1	N	B
6017.80		1	N	U
6161.19	39	1	R	U
6182.34		1	N	B
6281.31		1	N	U
6475.29		1	N	U
6564.63		1	N	U
6566.75		1	N	BB
6673.78		1	N	BB
Pr				
3492.73		1	M	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Pr (Continued)				
3508.21		1	N	B
3528.71		1	M	B
3752.69		2	M	BB
3770.21		2	M	B
3819.07		2	N	B
3903.91		2	N	B
50.66		2	N	U
3985.66		2	N	B
4000.90		2	N	B
4107.11		2	N	U
4138.19		2	N	B
4223.51		2	N	B
75.19		2	N	U
76.19		2	N	BB
4278.62		2	N	B
4331.29		2	N	BB
4388.73		2	M	B
4420.30		2	M	U
41.09		2	M	B
73.32		2	M	B
4487.08		2	M	B
4504.59		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Pr (Continued)				
4537.39		3	M	BB
4572.30		3	M	B
4650.88		3	M	BB
4712.29		3	M	BB
4850.28		3	M	BB
4928.40		3	M	BB
29.35		3	M	BB
29.37		3	M	BB
35.14		3	M	BB
4942.31		3	M	BB
5342.55		1	N	B
5553.40		1	N	U
5690.95		1	N	B
5691.04		1	N	B
5719.81		1	N	B
5728.36		1	N	B
5878.11		1	N	BB
5994.92		1	N	CB
6884.72		1	N	BB
6892.76		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NdI				
3976.09		2	N	U
4311.25		2	N	B
4529.94		3	N	B
4548.24		3	N	U
4609.87		3	N	B
37.20		3	N	B
73.97		3	N	U
4683.45		3	N	BB
4719.02		3	N	B
70.20		3	N	BB
4779.46		3	N	B
4853.33		3	N	BB
55.31		3	N	BB
59.58		3	N	B
4896.93		3	N	BB
4907.26		3	N	U
50.29		3	N	B
50.67		3	N	BB
52.46		3	N	BB
54.78		3	N	B
75.50		3	N	U
4980.88		3	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NdI (Continued)				
4982.89		3	N	U
4988.97		3	N	B
5105.35		1	N	U
5291.67		1	N	B
5377.79		1	N	B
5378.23		1	N	BB
5449.24		1	N	B
92.30		1	N	B
93.34		1	N	B
5496.42		1	N	B
5529.07		1	N	B
61.17		1	N	U
5592.67		1	N	U
5601.92		1	N	BB
35.76		1	N	U
69.77		1	N	BB
5676.33		1	N	B
5784.96		1	N	B
5867.08		1	N	U
86.24		1	N	U
5887.91		1	N	U
5922.79		1	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NdI (Continued)				
5994.76		1	N	CB
6155.06		1	N	B
6223.39		1	N	BB
6282.00		1	N	U
6485.69		1	N	U
6670.37		1	N	U
6712.27		1	N	BB
6763.01		1	N	BB
6852.23		1	N	B
6886.86		1	N	BB
6906.07		1	N	U
23.86		1	N	U
6932.16		1	N	U
NdII				
3543.35	Unclassified	1	R	B
3728.13		2	N	BB
38.06		2	N	BB
52.68	33	2	R	BB
3779.47		2	N	U
3809.06		2	N	B
26.42	33	2	R	B
3829.16		2	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NdII (Continued)				
3838.98	28	2	R	U
51.74		2	N	U
80.38		2	N	U
87.87		2	N	BB
3897.63		2	N	B
3948.32		2	N	U
63.11	39	2	R	U
73.69		2	N	U
81.24		2	N	B
82.36	67	2	R	B
91.74	19	2	R	B
94.68	Unclassified	2	R	B
95.26		2	N	B
3997.44		2	N	B
4004.02	Unclassified	2	R	B
18.81	19	2	R	B
21.34	36	2	R	U
23.00	Unclassified	2	R	U
4030.47	32	2	R	B
4109.08	17	2	R	U
10.48	15	2	R	B
4156.08	10	2	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NdII (Continued)				
4156.27	14	2	R	U
65.04		2	N	U
4175.61	39	2	R	U
4214.22		2	N	U
20.25		2	N	U
21.33		2	N	U
4229.50		2	N	CB
4304.45		2	N	U
58.17	10	2	R	BB
68.64		2	N	B
71.07	57	2	R	U
72.28		2	N	U
72.73		2	N	U
4376.45		2	N	B
4414.43	3	2	R	CB
65.08	5	2	R	U
85.95		2	N	BB
4497.27		2	N	U
4513.34		2	N	B
23.58		2	N	U
42.61	Unclassified	3	R	CB
4556.13	6	3	R	CB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NdII (Continued)				
4567.61	49	3	R	CB
69.85	5	3	R	BB
78.89		3	N	BB
94.45	52	3	R	B
4597.02		3	N	B
4612.47		3	N	U
4680.74	4	3	R	B
4703.58	55	3	R	BB
06.54	3	3	R	U
24.35		3	N	B
36.20		3	N	B
63.87	6	3	R	B
4789.41		3	N	B
4825.48	3	3	R	U
28.58		3	N	U
35.98	1	3	R	B
49.06		3	N	B
4889.10		3	N	B
4902.03		3	N	U
30.72		3	N	B
43.90		3	N	B
4954.78		3	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NdII (Continued)				
4958.10		3	N	BB
59.13	1	3	R	U
61.40	22	3	R	U
70.93		3	N	B
81.28		3	N	BB
89.94		3	N	U
4998.55		3	N	U
5077.16		1	N	U
5102.49		1	N	U
07.59		1	N	B
5191.45	45	1	R	B
5215.65		1	N	B
25.05		1	N	B
5239.79		1	N	B
5311.46	80	1	R	BB
61.47	74	1	R	B
5371.94	79	1	R	B
5442.27	76	1	R	B
51.12	Unclassified	1	R	U
5483.12		1	N	B
5539.26		1	N	B
5545.91		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NdII (Continued)				
5620.62	86	1	R	B
5668.87	84	1	R	U
5702.24	78	1	R	B
08.28	79	1	R	B
5743.20		1	N	BB
5865.06		1	N	U
5882.78		1	N	U
5909.87		1	N	BB
5934.75	78	1	R	B
6031.27		1	N	B
6034.24		1	N	B
6170.49		1	N	B
6183.91		1	N	B
6201.74		1	N	BB
6263.23		1	N	BB
6361.43		1	N	B
6425.79		1	N	U
6480.21		1	N	B
6523.15		1	N	BB
6698.65		1	N	BB
6790.41		1	N	U
6812.30		1	N	BB

TABLE III (Continued)

λ	Multiplet	Measurements	Source	Comments
NdII (Continued)				
6926.87		1	N	BB
6941.39		1	N	U
Nd				
3484.09		1	M	U
3504.08		1	M	BB
3582.63		1	N	B
3606.30		1	N	U
3720.54		2	N	U
26.35		2	M	U
3756.09		2	M	U
3864.90		2	N	B
4273.74		2	M	CB
4280.17		2	N	B
4312.08		2	M	B
4365.23		2	M	U
4402.47		2	M	B
28.99		2	M	B
31.87		2	M	BB
4487.62		2	M	U
4571.04		3	M	BB
4581.20		3	M	BB
5136.83		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Nd (Continued)				
5533.40		1	M	BB
5950.47		1	M	BB
5994.03		1	M	CB
6082.90		1	M	U
6431.71		1	M	BB
6636.15		1	N	U
6764.61		1	N	BB
6901.33		1	N	BB
6940.14		1	N	U
PmII				
3427.40		1	JR	B
3460.25		1	JR	B
3559.47		1	JR	BB
3565.32		1	JR	B
3629.85		2	JR	BB
41.65		2	JR	BB
51.25		2	JR	B
3692.52		2	JR	U
3742.51		2	JR	B
91.20		2	JR	B
95.66		2	JR	B
3798.39		2	JR	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PmII (Continued)				
3815.82		2	JR	B
31.53		2	JR	BB
86.56		2	JR	B
92.16		2	JR	B
3899.78		2	JR	B
3910.26		2	JR	B
19.09		2	JR	B
36.47		2	JR	BB
44.23		2	JR	BB
57.74		2	JR	BB
87.90		2	JR	BB
95.05		2	JR	BB
3998.96		2	JR	BB
4012.71		2	JR	B
14.20		2	JR	B
19.34		2	JR	BB
23.70		2	JR	B
69.90		2	JR	B
75.85		2	JR	CB
81.74		2	JR	B
4086.10		2	JR	B
4139.72		2	JR	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PmII (Continued)				
4140.46		2	JR	B
51.60		2	JR	B
61.21		2	JR	B
4161.50		2	JR	B
4228.35		2	JR	U
4277.52		2	JR	CB
4332.04		2	JR	U
65.07		2	JR	U
4388.76		2	JR	B
4404.26		2	JR	B
19.35		2	JR	B
21.15		2	JR	B
46.90		2	JR	B
53.96		2	JR	CB
4477.46		2	JR	CB
4513.54		2	JR	U
4525.19		2	JR	B
4739.08		3	JR	B
4860.73		3	JR	BB
4901.25		3	JR	U
02.05		3	JR	U
4974.74		3	JR	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PmII (Continued)				
4979.53		3	JR	B
5005.79		1	JR	U
5058.29		1	JR	U
5119.36		1	JR	U
5170.77		1	JR	U
5203.76		1	JR	U
5302.01		1	JR	BB
5445.79		1	JR	U
5520.84		1	JR	U
56.86		1	JR	U
80.68		1	JR	U
82.62		1	JR	BB
5596.58		1	JR	BB
5604.07		1	JR	U
41.28		1	JR	U
5662.36		1	JR	U
5729.83		1	JR	U
5734.75		1	JR	U
5917.39		1	JR	U
92.44		1	JR	BB
5995.24		1	JR	U
6006.10		1	JR	CB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PmII (Continued)				
6050.15		1	JR	U
6096.04		1	JR	U
6275.88		1	JR	BB
6475.93		1	JR	B
6488.22		1	JR	U
6706.27		1	JR	BB
6787.81		1	JR	BB
6843.07		1	JR	U
SmI				
3925.22	2	2	R	U
4331.45		2	N	B
4357.90		2	N	B
4403.13		2	N	B
19.33		2	N	B
63.90		2	N	U
4499.11		2	N	U
4566.77		3	N	U
4581.73		3	N	BB
4649.49		3	N	U
4728.42		3	N	B
57.72		3	N	B
4770.20		3	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmI (Continued)				
4783.10		3	N	U
4785.86		3	N	U
4841.70	2	3	R	CB
48.32		3	N	B
4883.77		3	N	B
4946.32		3	N	B
4975.98		3	N	U
5117.16		1	N	B
5175.42		1	N	U
5201.45		1	N	U
5221.12		1	N	U
5313.76		1	N	B
70.06		1	N	B
5378.09		1	N	BB
5433.82		1	N	U
5493.72		1	N	B
5512.10		1	N	B
48.95		1	N	BB
74.89		1	N	U
5588.20		1	N	U
5717.92		1	N	B
5802.84		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmI (Continued)				
5814.89		1	N	BB
30.51		1	N	U
91.41		1	N	B
95.16		1	N	B
5898.96		1	N	B
5910.83		1	N	B
12.61		1	N	U
16.36		1	N	B
32.18		1	N	B
5946.37		1	N	B
6027.16		1	N	B
84.12		1	N	B
6089.62		1	N	B
6135.85		1	N	BB
6139.33		1	N	U
6201.13		1	N	BB
6588.91	1	1	R	BB
6671.51	1	1	R	BB
6723.26		1	N	B
6827.81		1	N	U
30.54		1	N	BB
6838.33		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmI (Continued)				
6912.78		1	N	U
6918.78		1	N	BB
SmII				
3418.15		1	N	U
18.51	47	1	R	U
24.78		1	N	U
3452.77		1	N	B
3539.26		1	N	B
3601.69		1	N	B
04.29	47	1	R	U
09.49	30	1	R	U
27.01	30	2	R	B
27.97	12	2	R	U
31.13	Unclassified	2	R	CB
3670.84	11	2	R	CB
3708.65	19	2	R	B
28.93		2	N	U
31.26		2	N	CB
39.12	Unclassified	2	R	U
40.75		2	M	U
56.54		2	N	U
3762.59	25	2	R	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmII (Continued)				
3772.64		2	N	U
83.06		2	N	B
3788.13	25	2	R	U
3800.37	43	2	R	U
31.50		2	N	BB
35.72		2	N	U
55.90		2	N	B
62.05	10	2	R	B
82.50		2	N	CB
90.05	17	2	R	B
3894.05		2	N	B
3918.62		2	N	U
22.05		2	N	B
22.40	38	2	R	U
28.28	17	2	R	B
41.87	1	2	R	U
76.43	33	2	R	U
79.20	51	2	R	B
86.00		2	N	B
86.90		2	N	B
90.00		2	N	B
3990.02		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmII (Continued)				
4006.60		2	N	B
07.48		2	N	B
19.98	16	2	R	CB
35.11	33	2	R	U
37.10		2	N	U
41.68	22	2	R	U
64.58	24,33	2	R	B
75.81	51	2	R	CB
92.27		2	N	U
4093.04		2	N	U
4108.32		2	N	U
18.55	54	2	R	U
21.54		2	N	B
25.85		2	N	B
29.23	24	2	R	B
53.33	54	2	R	B
55.22	8,50	2	R	CB
74.43		2	N	B
78.02	16,50	2	R	B
4181.10		2	N	B
4202.92		2	N	U
4206.13		2	N	CB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmII (Continued)				
4223.70		2	N	CB
34.57	42	2	R	B
36.74	53	2	R	U
53.72		2	N	B
69.77		2	N	B
79.94		2	N	U
80.79	46	2	R	BB
4292.74		2	N	B
4318.94	27	2	R	BB
23.28	8	2	R	CB
29.02	15	2	R	B
34.15	27	2	R	U
4378.24	53	2	R	CB
4420.53	32	2	R	B
46.96		2	N	U
85.57		2	N	U
4499.48	23	2	R	U
4511.83	14	2	R	U
36.51		3	N	CB
38.53		3	N	U
60.43		3	N	U
4566.21	32	3	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmII (Continued)				
4579.09		3	N	CB
81.58		3	N	CB
84.83		3	N	B
4595.29	45	3	R	CB
4604.18		3	N	B
15.44	49	3	R	B
15.69	27	3	R	B
30.21		3	N	B
46.68	26	3	R	B
69.40	7	3	R	B
76.91	3	3	R	BB
87.18	3	3	R	U
88.73		3	N	BB
4699.34		3	N	U
4710.64		3	N	U
20.12		3	N	B
26.02		3	N	B
45.68	7	3	R	B
53.29		3	M	U
74.15		3	N	BB
81.84		3	N	B
4791.58	7	3	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmII (Continued)				
4815.81	14	3	R	BB
16.01	41	3	R	BB
34.62	45	3	R	U
44.21	26	3	R	U
54.37	36	3	R	BB
4891.94		3	N	BB
4913.25	53	3	R	U
29.56		3	N	U
33.30		3	M	B
38.10	23	3	R	B
40.62		3	M	B
41.39		3	M	BB
48.63	49	3	R	B
52.37	32	3	R	BB
53.03		3	N	BB
55.95		3	N	BB
56.13		3	N	B
61.94	41	3	R	B
72.16		3	N	B
81.73		3	N	B
4983.38		3	N	B
5100.20		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmII (Continued)				
5103.09		1	N	U
04.48		1	N	B
54.23		1	N	CB
5157.23		1	N	U
5637.30		1	N	U
5781.93		1	N	BB
5786.98		1	N	B
5878.20		1	N	CB
5903.50		1	N	BB
19.33		1	N	U
32.90		1	N	U
38.90		1	N	BB
57.52		1	N	B
63.22		1	N	B
5994.64		1	N	CB
6017.39		1	N	BB
6104.82		1	M	U
10.19		1	M	BB
10.66		1	N	BB
64.51		1	N	U
6188.00		1	N	BB
6291.82		1	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmII (Continued)				
6329.38		1	M	BB
6390.81		1	N	B
6570.67		1	N	U
6604.56		1	N	BB
17.61		1	N	B
30.61		1	N	U
6693.55		1	N	U
6731.84	59	1	R	BB
34.81		1	N	BB
54.68		1	N	BB
66.52		1	N	BB
78.61		1	N	U
80.03		1	N	BB
90.00	56	1	R	BB
6793.55		1	N	B
6829.86		1	N	B
46.54		1	N	B
48.88		1	M	B
61.10		1	N	BB
85.16		1	N	BB
6887.42		1	N	B
6900.28		1	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmII (Continued)				
6927.03		1	N	U
29.60		1	N	BB
41.56		1	N	BB
50.51		1	N	B
55.29		1	N	U
55.63		1	N	U
6958.97		1	N	B
Sm				
4445.88		2	N	B
4578.00		3	M	CB
4794.31		3	M	CB
4965.79		3	M	BB
4974.73		3	M	U
5351.56		1	M	BB
5366.77		1	M	B
5661.17		1	M	B
5725.59		1	M	B
5750.73		1	M	B
5813.06		1	M	B
32.36		1	M	CB
5896.87		1	M	BB
5993.85		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Sm (Continued)				
6047.46		1	M	B
59.87		1	M	U
63.66		1	M	B
6092.91		1	M	BB
6103.37		1	N	U
92.64		1	N	U
6197.39		1	M	B
6210.45		1	M	U
19.17		1	M	B
25.48		1	N	U
76.77		1	M	U
6297.64		1	M	B
6357.18		1	N	B
6469.00		1	M	U
69.76		1	M	B
73.34		1	M	BB
6483.37		1	M	B
6507.13		1	M	B
67.50		1	M	BB
6593.03		1	M	BB
6640.49		1	M	BB
6668.60		1	M	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Sm (Continued)				
6695.31		1	M	BB
6809.23		1	M	BB
15.54		1	M	CB
57.72		1	M	CB
68.13		1	M	U
77.27		1	M	B
6891.48		1	M	CB
6925.70		1	M	CB
35.38		1	M	U
48.18		1	M	BB
6952.39		1	M	B
EuI				
4298.73		2	N	B
4329.97		2	N	U
4594.03	1	3	R	B
4661.88		3	N	B
4849.64		3	N	U
4900.86		3	N	B
53.52		3	N	B
60.21		3	N	U
4962.55		3	N	B
5129.10		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
EuI (Continued)				
5130.08		1	N	B
5199.85		1	N	BB
5271.96		1	N	B
5355.10		1	N	B
5361.61		1	N	CB
5402.77		1	N	B
52.94		1	N	U
5495.20		1	N	U
5542.54		1	N	U
79.63		1	N	B
5586.83		1	N	B
5621.44		1	N	B
73.85		1	N	U
5681.10		1	N	U
5783.69		1	N	U
5915.74		1	N	B
67.10		1	N	BB
5972.75		1	N	BB
6012.20		1	N	B
44.66		1	N	U
49.51	9	1	R	B
6099.35		1	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
EuI (Continued)				
6118.78		1	N	U
6262.25		1	N	B
66.95		1	N	BB
6285.95		1	N	B
6318.58		1	N	B
6369.25		1	N	U
6501.55		1	N	U
6519.59		1	N	B
6787.48		1	N	CB
6816.06		1	N	BB
34.30		1	N	BB
44.83		1	N	CB
6864.54		1	N	CB
6903.67		1	N	U
10.17		1	N	U
6914.82		1	N	U
EuII				
3419.84		1	N	U
26.44		1	N	U
3437.57		1	N	BB
3505.31		1	N	U
3508.85	13	1	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
EuII (Continued)				
3521.09	24	1	R	U
3603.20	16	1	R	B
22.54	18	2	R	U
3673.20	28	2	R	U
3741.31	11	2	R	U
3799.01	11	2	R	U
3844.23		2	N	U
3877.27		2	N	U
3928.87	10	2	R	U
30.50	5	2	R	B
51.33		2	N	B
64.90	10	2	R	BB
79.63		2	N	B
88.24		2	N	B
3993.93		2	N	B
4096.80		2	N	B
4136.59		2	N	B
41.02		2	N	B
51.52	10	2	R	B
51.64		2	N	B
4175.16		2	N	B
4221.08		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
EuII (Continued)				
4232.45		2	N	B
4253.80		2	N	B
4334.75	12	2	R	U
4405.27		2	N	CB
5818.74	9	1	R	U
5872.98	9	1	R	U
5953.84		1	N	U
5966.07	9	1	R	U
6173.05	9	1	R	U
6303.41	8	1	R	U
6437.64	8	1	R	U
6645.11	8	1	R	U
Eu				
3511.07		1	M	U
11.18		1	M	U
13.34		1	M	U
3544.77		1	M	U
3723.84		2	N	BB
44.55		2	N	B
3780.51		2	M	B
3804.26		2	M	BB
3861.96		2	M	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Eu (Continued)				
4122.94		2	M	U
4210.67		2	M	B
40.12		2	M	B
4257.85		2	M	U
4301.56		2	M	U
11.31		2	N	B
17.67		2	M	U
22.58		2	M	BB
66.52		2	M	B
76.41		2	M	B
91.37		2	M	U
4397.71		2	M	B
4422.96		2	M	U
26.42		2	M	U
30.80		2	M	B
40.04		2	M	U
77.18		2	M	U
4497.53		2	M	U
4508.70		2	M	B
70.50		3	M	B
4576.93		3	M	U
4686.66		3	M	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Eu (Continued)				
4697.59		3	M	B
4725.70		3	M	U
4928.01		3	M	CB
4932.82		3	M	CB
5278.16		1	M	B
5599.10		1	M	U
5649.87		1	M	U
5767.62		1	M	U
5820.00		1	M	B
5964.76		1	M	CB
6153.22		1	M	BB
6300.50		1	M	U
6360.47		1	M	BB
6758.53		1	M	U
6782.7		1	M	U
GdI				
3674.05		2	N	CB
3783.05		2	N	B
3912.75		2	N	U
3974.81		2	N	B
4006.96		2	N	B
4015.58		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdI (Continued)				
4023.14		2	N	BB
27.61		2	N	B
50.37		2	N	BB
4080.53		2	N	CB
4125.78		2	N	B
4190.79		2	N	U
4208.08		2	N	U
4285.82		2	N	B
4321.20		2	N	B
28.94		2	N	B
36.78		2	N	U
4378.56		2	N	U
4403.14		2	N	B
4572.20		3	N	CB
75.91		3	N	U
86.99		3	N	B
4598.90		3	N	U
4614.50		3	N	U
24.42		3	N	B
36.64		3	N	B
80.04		3	N	U
4683.07		3	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdI (Continued)				
4688.12		3	N	U
94.33		3	N	U
4697.42		3	N	B
4735.75		3	N	B
43.65		3	N	U
45.82		3	N	B
60.74		3	N	U
63.82		3	N	B
67.24		3	N	U
4786.75		3	N	B
4829.94		3	N	BB
56.17		3	N	B
56.72		3	N	U
59.22		3	N	B
62.59		3	N	B
71.50		3	N	B
4881.08		3	N	U
4936.33		3	N	B
50.11		3	N	B
51.56		3	N	B
52.47		3	N	CB
4953.13		3	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdI (Continued)				
4958.79		3	N	B
61.47		3	N	B
4969.16		3	N	U
5015.04	6	1	R	B
5136.04		1	N	B
5155.84	6	1	R	U
5251.18	6	1	R	U
5272.37		1	N	B
5321.25		1	N	B
65.38		1	N	B
5389.50		1	N	B
5548.20		1	N	B
5709.42		1	N	B
5724.75		1	N	U
5930.29		1	N	U
37.71		1	N	B
5999.08		1	N	BB
6114.07	3	1	R	U
6538.15		1	N	BB
6653.55		1	N	CB
6814.56		1	N	CB
6828.25	2	1	R	CB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII				
3416.95	22	1	R	U
18.73	7	1	R	U
22.75	8	1	R	B
24.59	22	1	R	U
25.62	91	1	R	B
27.36	91	1	R	U
28.47	90	1	R	U
30.24	91	1	R	U
39.21	23	1	R	U
39.99	7	1	R	CB
50.38	22	1	R	B
51.23	22	1	R	B
67.27	22	1	R	U
73.22	7	1	R	U
81.28	22	1	R	U
81.80	22	1	R	U
91.74		1	N	U
91.95	6	1	R	U
3494.40	7	1	R	U
3505.51	22	1	R	U
12.22	38	1	R	U
3512.50	89	1	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII (Continued)				
3516.78		1	N	U
24.20	6	1	R	B
37.15		1	N	B
44.99	51	1	R	CB
45.80	2	1	R	U
49.37	7	1	R	U
57.05	22	1	R	B
64.05	52	1	R	B
67.65	51	1	R	U
81.92	69	1	R	U
84.96	7	1	R	U
3592.71	69	1	R	U
3600.96	68	1	R	U
10.91		1	N	CB
45.62	17	2	R	U
50.95	69	2	R	U
3697.73	4	2	R	U
3779.83		2	N	B
3805.09		2	N	BB
18.75		2	N	U
27.33		2	N	B
3863.05		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII (Continued)				
3902.40	19	2	R	B
23.25	50	2	R	B
69.29	20	2	R	B
71.06	50	2	R	U
73.98	50	2	R	CB
75.11		2	N	U
83.01	49	2	R	U
87.21	19	2	R	U
93.21	1	2	R	U
94.16	49	2	R	U
96.32	Unclassified	2	R	B
3997.76	67	2	R	B
4004.94		2	N	B
08.91	Unclassified	2	R	B
46.84		2	N	U
53.29	Unclassified	2	R	U
4098.90	49	2	R	U
4111.44	Unclassified	2	R	B
41.02	117	2	R	B
53.51	117	2	R	B
63.09	44	2	R	B
4184.25	15	2	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII (Continued)				
4225.15	14	2	R	B
32.47		2	N	CB
41.28	117	2	R	B
96.30	117	2	R	U
4298.43		2	N	U
4308.23	47	2	R	U
80.64	68	2	R	U
87.67	15	2	R	U
4397.51	Unclassified	2	R	U
4427.61	66	2	R	U
53.93	64	2	R	CB
4494.85	14	2	R	B
4506.93	13	2	R	CB
10.38	30	2	R	U
21.30	44	2	R	U
58.08	44	3	R	CB
96.98		3	N	B
4597.91	44	3	N	U
4639.00	64,102	3	R	B
4654.99	65	3	R	B
4711.98		3	N	U
4712.80		3	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII (Continued)				
4719.04	43	3	R	B
26.73	148	3	R	U
28.47	65	3	R	B
32.60	65	3	R	U
34.43	43	3	R	BB
4772.73	133	3	R	B
4834.23	65	3	R	U
4839.62	126	3	R	CB
4910.84	64	3	R	U
16.78	125	3	R	U
36.16	116	3	R	BB
54.02	114	3	R	U
58.79	64	3	R	B
65.05	143	3	R	B
68.57	124	3	R	B
73.90	64	3	R	BB
4985.30		3	N	U
5010.82	59	1	R	B
19.36	81	1	R	U
31.29	114	1	R	CB
5050.88	114	1	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII (Continued)				
5061.06		1	N	BB
62.86	64	1	R	U
67.06		1	N	B
92.25	114	1	R	U
5096.06	59	1	R	U
5108.91	114	1	R	B
23.65		1	N	BB
25.56	49	1	R	BB
30.28	115	1	R	B
40.84	115	1	R	U
60.90	115	1	R	B
64.54	97	1	R	U
76.28	60	1	R	U
78.10	114	1	R	U
78.84		1	N	B
86.91	114	1	R	BB
5199.21	115	1	R	U
5220.30	80	1	R	B
5315.79		1	N	B
16.80		1	N	B
57.79	62	1	R	B
5372.22	99	1	R	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII (Continued)				
5394.32	63	1	R	BB
5412.64		1	N	B
19.88	99	1	R	U
41.17	146	1	R	BB
5470.53	63	1	R	U
5500.43	99	1	R	BB
24.60		1	N	B
38.32	Unclassified	1	R	B
60.69	99	1	R	BB
83.68	54	1	R	U
86.16	78	1	R	U
5597.21	95	1	R	U
5621.43	132	1	R	B
5721.99	110	1	R	U
28.32	60	1	R	B
33.86	94	1	R	U
5749.41	97	1	R	CB
5801.30	112	1	R	U
15.85	112	1	R	U
20.99	112	1	R	U
40.47	112	1	R	U
5845.71	112	1	R	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII (Continued)				
5855.22	112	1	R	B
56.96	60	1	R	U
71.81	79	1	R	U
77.26	94	1	R	U
5897.62	112	1	R	U
5904.07	112	1	R	U
51.60	95	1	R	U
56.48	59	1	R	U
5987.11	97	1	R	B
6004.57	112	1	R	B
11.12	60	1	R	CB
49.50	59	1	R	B
6080.65	112	1	R	U
6106.19	95	1	R	U
6180.42	111	1	R	U
6260.31	111	1	R	U
6305.15	94	1	R	U
6480.11	109	1	R	B
6634.36	94	1	R	BB
6679.56		1	N	U
6702.12	130	1	R	BB
6752.67	130	1	R	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
GdII (Continued)				
6753.91		1	N	U
6846.60	94	1	R	B
6887.63	Unclassified	1	R	B
6900.73	122	1	R	CB
20.62	122	1	R	U
24.99		1	N	BB
6957.74		1	N	U
Gd				
3696.77		2	N	U
4428.94		2	M	B
4513.81		2	M	U
4575.84		3	M	BB
4705.77		3	M	B
4723.73		3	M	B
4939.55		3	M	BB
5469.04		1	M	B
5534.29		1	M	BB
5622.91		1	M	U
5643.68		1	M	U
5882.16		1	M	U
5970.31		1	M	U
6231.62		1	M	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Gd (Continued)				
6460.56		1	M	BB
6530.98		1	M	U
6542.04		1	M	U
6800.70		1	M	BB
22.73		1	M	BB
6834.82		1	M	BB
6919.61		1	M	B
37.49		1	M	U
43.07		1	M	BB
44.99		1	M	BB
6947.24		1	M	U
TbI				
3523.20		1	N	B
3745.07		2	N	U
3879.99		2	N	U
3987.67		2	N	B
4010.06		2	N	B
36.24		2	N	U
60.40		2	N	U
4074.16		2	N	U
4139.06		2	N	U
4171.05		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TbI (Continued)				
4172.60		2	N	B
4218.86		2	N	B
64.98		2	N	U
66.34		2	N	U
69.69		2	N	U
4293.13		2	N	B
4304.27		2	N	B
11.29		2	N	B
18.85		2	N	BB
25.50		2	N	BB
38.45		2	N	U
62.44		2	N	U
4396.56		2	N	B
4556.46		3	N	U
4786.78		3	N	B
4813.77		3	N	B
4926.83		3	N	B
71.42		3	N	B
4980.56		3	N	BB
5108.56		1	N	BB
5147.58		1	N	BB
5309.46		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TbI (Continued)				
5803.13		1	N	CB
5937.09		1	N	U
6038.97		1	N	U
TbII				
3416.24		1	N	U
44.58		1	N	U
3487.62		1	N	B
3509.17		1	N	U
3601.75		1	N	B
04.90		1	N	B
3611.33		1	N	B
3851.86		2	N	BB
68.90		2	N	BB
3899.20		2	N	BB
3923.31		2	N	CB
24.81		2	N	B
35.24		2	N	U
39.52		2	N	B
81.89		2	N	U
85.08		2	N	B
3997.43		2	N	B
4000.01		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TbII (Continued)				
4002.59		2	N	B
4097.48		2	N	BB
4114.13		2	N	B
58.28		2	N	U
4179.79		2	N	B
4223.32		2	N	U
4312.08		2	N	B
4386.08		2	N	BB
4531.83		3	N	U
62.24		3	N	B
78.69		3	N	CB
4591.56		3	N	U
4641.00		3	N	U
4641.98		3	N	B
4707.94		3	N	B
4856.54		3	N	BB
4875.58		3	N	B
5402.06		1	N	B
5525.62		1	N	B
6104.29		1	N	BB
6677.94		1	N	B
6727.21		1	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TbII (Continued)				
6755.01		1	N	CB
6896.37		1	N	U
6902.08		1	N	B
Tb				
3575.90		1	N	U
4240.13		2	N	B
4273.74		2	M	CB
4430.74		2	M	B
4503.58		2	M	CB
4660.44		3	M	U
4753.52		3	M	BB
4954.52		3	M	CB
5450.16		1	M	U
5457.83		1	M	B
5832.94		1	M	CB
DyI				
3571.34		1	N	U
3772.65		2	N	B
3868.81		2	N	B
3944.30		2	N	BB
3967.50		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
DyI (Continued)				
3996.01		2	N	B
4038.84		2	N	B
45.99		2	N	B
4089.49		2	N	B
4129.13		2	N	B
46.07		2	N	U
67.99		2	N	B
70.55		2	N	B
71.93		2	N	B
4198.02		2	N	U
4214.38		2	N	U
4225.14		2	N	B
4389.78		2	N	U
4565.11		3	N	CB
4589.37		3	N	U
4774.80		3	N	BB
4775.80		3	N	U
4800.68		3	N	BB
24.99		3	N	B
32.44		3	N	B
87.08		3	N	CB
4893.69		3	N	CB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
DyI (Continued)				
4922.21		3	N	B
4973.58		3	N	BB
5024.51		1	N	U
5042.62		1	N	B
5165.31		1	N	B
5404.16		1	N	B
5496.84		1	N	CB
5547.28		1	N	U
5613.24		1	N	U
27.49		1	N	B
5646.02		1	N	B
5740.19		1	N	B
5745.54		1	N	BB
5984.86		1	N	B
6010.80		1	N	CB
17.27		1	N	BB
6085.04		1	N	BB
6168.43		1	N	B
6724.79		1	N	U
6835.44		1	N	BB
53.00		1	N	BB
6856.50		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
DyI (Continued)				
6888.90		1	N	CB
6895.55		1	N	BB
6925.48		1	N	CB
29.54		1	N	BB
42.17		1	N	U
45.35		1	N	U
51.49		1	N	BB
6958.08		1	N	B
DyII				
3413.79		1	N	U
18.13		1	N	B
19.63		1	N	U
22.58		1	N	CB
22.86		1	N	U
23.25		1	N	U
29.45		1	N	U
36.95		1	N	U
45.58		1	N	B
54.35		1	N	CB
68.44		1	N	U
77.94		1	N	B
3494.50		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
DyII (Continued)				
3498.67		1	N	U
3501.87		1	N	U
04.52		1	N	U
23.98		1	N	B
31.71		1	N	B
34.96		1	N	U
36.03		1	N	B
40.67		1	N	U
50.22		1	N	CB
51.59		1	N	U
58.21		1	N	U
63.14		1	N	U
76.25		1	N	B
91.43		1	N	U
3593.15		1	N	U
3600.34		1	N	U
06.13		1	N	U
17.24		2	N	CB
18.08		2	N	BB
32.79		2	N	CB
40.24		2	N	BB
3645.41		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
DyII (Continued)				
3648.79		2	N	CB
3697.31		2	N	U
3707.57		2	N	BB
10.73		2	N	U
85.42		2	N	B
86.21		2	N	B
3788.46		2	N	B
3804.14		2	N	CB
09.05		2	N	BB
16.77		2	N	CB
69.87		2	N	BB
3872.14		2	N	U
3913.98		2	N	B
23.39		2	N	B
32.97		2	N	B
44.70		2	N	U
54.56		2	N	B
91.33		2	N	B
96.70		2	N	U
3998.08		2	N	U
4000.48		2	N	U
4007.75		2	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
DyII (Continued)				
4010.08		2	N	B
11.32		2	N	U
15.18		2	N	U
33.67		2	N	U
41.98		2	N	B
4050.58		2	N	B
4103.34		2	N	U
06.38		2	N	U
11.34		2	N	B
4124.65		2	N	B
4328.90		2	N	CB
4431.00		2	N	U
68.14		2	N	B
4468.17		2	N	B
4573.85		3	N	B
4664.68		3	N	B
4682.02		3	N	CB
4760.02		3	N	B
4856.24		3	N	B
4890.11		3	N	U
4957.36		3	N	B
5090.38		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
DyII (Continued)				
5197.66		1	N	B
5272.25		1	N	B
5368.20		1	N	B
5369.26		1	N	B
5426.71		1	N	U
5443.35		1	N	B
5600.71		1	N	CB
5693.67		1	N	B
5844.41		1	N	U
5848.05		1	N	BB
5924.54		1	N	U
6594.16		1	N	U
6743.77		1	N	CB
6899.34		1	N	U
6906.57		1	N	U
32.62		1	N	CB
6950.29		1	N	CB
Dy				
3478.23		1	M	U
3540.34		1	M	CB
3818.74		2	N	B
3831.03		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Dy (Continued)				
3868.46		2	N	U
4237.54		2	N	U
4269.60		2	M	BB
4278.62		2	M	B
4332.92		2	M	BB
4366.11		2	M	B
4411.37		2	M	BB
4735.49		3	M	U
4776.89		3	M	U
4802.08		3	M	BB
4841.78		3	N	CB
4931.00		3	M	CB
45.51		3	M	BB
4975.00		3	M	BB
5398.26		1	N	B
5660.28		1	M	U
6038.68		1	M	B
63.56		1	M	CB
6099.62		1	M	CB
HoI				
3794.69		2	N	B
3796.75		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
HoI (Continued)				
3810.73		2	N	B
3890.43		2	N	B
3919.45		2	N	U
3975.88		2	N	B
4057.55		2	N	B
4087.35		2	N	B
4112.00		2	N	B
35.08		2	N	B
39.34		2	N	CB
63.03		2	N	B
4194.35		2	N	B
4578.07		3	N	U
4608.00		3	N	B
32.84		3	N	B
4683.08		3	N	B
4711.39		3	N	U
17.52		3	N	B
4779.42		3	N	B
4892.35		3	N	U
4939.01		3	N	BB
46.80		3	N	B
4979.94		3	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
HoI (Continued)				
5042.37		1	N	B
5093.07		1	N	U
5182.11		1	N	B
5330.11		1	N	B
5384.97		1	N	U
5534.33		1	N	BB
5674.70		1	N	BB
5691.47		1	N	B
5839.47		1	N	U
5892.56		1	N	B
5933.71		1	N	B
6607.47		1	N	U
28.35		1	N	BB
28.99		1	N	BB
6652.98		1	N	CB
6883.36		1	N	BB
6939.49		1	N	B
6950.39		1	N	B
HoII				
3416.46		1	N	U
21.63		1	N	U
3426.76		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
HoII (Continued)				
3437.91		1	N	U
56.00		1	N	B
3493.09		1	N	U
3618.08		2	N	BB
3674.36		2	N	U
3874.68		2	N	B
3912.44		2	N	B
24.55		2	N	B
72.64		2	N	U
3985.71		2	N	B
4002.59		2	N	B
14.20		2	N	U
54.48		2	N	B
4065.09		2	N	CB
4447.23		2	N	U
4567.82		3	N	B
4609.32		3	N	B
09.52		3	N	B
49.77		3	N	B
4652.71		3	N	U
4812.92		3	N	B
4832.31		3	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
HoII (Continued)				
4889.67		3	N	BB
4896.44		3	N	B
4959.42		3	N	B
4967.21		3	N	U
5573.96		1	N	U
Ho				
3538.97		1	M	CB
3544.07		1	M	B
3851.54		2	N	BB
4223.64		2	M	B
5142.59		1	N	B
49.59		1	N	B
5190.11		1	N	CB
5485.28		1	M	U
5563.6		1	N	B
5736.4		1	N	B
5751.12		1	N	BB
6306.68		1	N	B
ErI				
3431.06		1	N	U
3810.33		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ErI (Continued)				
3899.04		2	N	B
3976.74		2	N	U
82.33		2	N	B
3987.66		2	N	B
4016.36		2	N	B
4098.11		2	N	B
4232.47		2	N	B
4331.35		2	N	B
4338.33		2	N	B
4414.34		2	N	CB
4512.18		2	N	B
92.93		3	N	B
4598.13		3	N	B
4673.16		3	N	U
4722.71		3	N	B
4745.11		3	N	B
4857.43		3	N	BB
4925.03		3	N	B
44.36		3	N	BB
4966.99		3	N	CB
5468.32		1	N	B
5516.00		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ErI (Continued)				
5622.02		1	N	B
5784.64		1	N	BB
5881.14		1	N	U
5909.25		1	N	U
5946.36		1	N	B
6014.83		1	N	U
6022.56		1	N	U
6268.86		1	N	BB
74.96		1	N	B
6299.41		1	N	B
6308.79		1	N	U
6583.46		1	N	U
6766.62		1	N	BB
6779.86		1	N	BB
6825.99		1	N	BB
6880.01		1	N	U
ErII				
3417.28		1	N	CB
17.64		1	N	B
77.94		1	N	B
3492.54		1	N	U
3604.72		1	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ErII (Continued)				
3692.64		2	N	B
3830.53		2	N	U
3880.60		2	N	BB
3911.58		2	N	B
12.43		2	N	B
3995.26		2	N	CB
4048.35		2	N	U
4378.35		2	N	CB
4419.62		2	N	B
4500.75		2	N	U
4630.90		3	N	B
4675.62		3	N	U
4702.19		3	N	U
4795.50		3	N	CB
4851.64		3	N	BB
54.42		3	N	B
61.60		3	N	U
72.10		3	N	B
4872.49		3	N	B
4925.43		3	N	B
27.36		3	N	B
4951.74		3	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ErII (Continued)				
4953.60		3	N	B
54.67		3	N	BB
4966.63		3	N	BB
5028.90		1	N	U
5029.76		1	N	U
5179.48		1	N	U
5218.24		1	N	BB
5395.87		1	N	U
5757.62		1	N	B
6015.76		1	N	U
6032.14		1	N	U
6761.69		1	N	U
6768.44		1	N	BB
6897.53		1	N	U
6944.95		1	N	B
Er				
3446.36		1	M	U
3547.51		1	N	U
3561.89		1	M	U
3612.88		1	M	B
3855.93		2	N	B
4160.30		2	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Er (Continued)				
4184.06		2	M	U
4484.47		2	N	BB
4488.89		2	N	B
4567.74		3	M	B
4941.85		3	M	BB
5090.27		1	M	B
5958.94		1	N	U
TmI				
3429.33		1	N	U
3499.95		1	N	B
3555.82		1	N	U
3949.28	2	2	R	U
4105.84	Unclassified	2	R	U
4359.93	1	2	R	B
4386.43	1	2	R	U
4454.04		2	N	CB
4599.02		3	N	B
4675.10		3	N	B
4681.92		3	N	B
4759.90		3	N	B
4808.68		3	N	U
4835.76		3	N	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TmI (Continued)				
4851.75		3	N	CB
4978.90		3	N	U
5760.21		1	N	U
6025.45		1	N	B
6352.66		1	N	BB
6657.78		1	N	BB
6788.52		1	N	BB
6844.28		1	N	BB
TmII				
3425.08	7	1	R	U
3425.63	3	1	R	U
3513.02		1	N	B
3599.16		1	N	U
3890.53	1	2	R	B
3900.79	9	2	R	U
4567.11		3	N	U
4826.99		3	N	U
31.20		3	N	B
4851.90		3	N	CB
4970.87		3	N	B
4975.12		3	N	U
5346.50		1	N	B

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TmII (Continued)				
5373.01		1	N	B
5461.96		1	N	BB
6181.42		1	N	U
Tm				
3528.19		1	M	U
4504.10		2	M	U
4505.52		2	M	U
6726.35		1	N	BB
6820.27		1	N	U
54.16		1	N	U
6898.58		1	N	B
6915.87		1	N	BB
YbI				
3911.28		2	N	B
4135.09		2	N	B
4439.21		2	N	B
4589.22		3	N	U
4590.84		3	N	U
4684.28		3	N	B
4935.51		3	N	B
5069.15		1	N	B
5524.55		1	N	BB

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
YbI (Continued)				
5539.09		1	N	B
5989.32		1	N	B
YbII				
3478.84		1	N	U
3694.19	1	2	R	U
3724.22		2	N	BB
4180.82		2	N	B
4553.59		3	N	U
4726.08		3	N	B
5300.95		1	N	U
5771.67		1	N	B
5908.38		1	N	U
6152.58		1	N	B
6934.04		1	N	B
Yb				
4247.89		2	M	B
4493.97		2	M	B
4503.61		2	M	CB
13.40		2	M	U
4567.36		3	M	B
4704.87		3	M	U

TABLE III (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Yb (Continued)				
4936.96		3	M	U
6111.28		1	M	BB
6150.64		1	M	U
6585.42		1	M	U
LuI				
3991.38		2	N	B
4054.45		2	N	B
4716.70		2	N	CB
4942.34		3	N	BB
5057.60		1	N	U
5421.90		1	N	B
6004.53	1	1	R	B
6477.67		1	N	BB
6523.18		1	N	BB
LuII				
3507.39	1	1	R	B
3876.65	3	2	R	BB
4184.25		2	JR	B
4785.42	5	3	R	B
4839.62	2	3	R	CB
4992.14	2	1	R	B

TABLE III (Concluded)

λ	Multiplet	Number of Measurements	Source	Comments
LuII (Continued)				
5983.90	2	1	R	B
6159.94		1	N	BB
6199.66		1	N	B
6242.34		1	N	U
6943.96		1	N	U
Lu				
4672.31		3	N	U
4684.16		3	N	B
4708.00		3	N	B
6611.80		1	M	B

TABLE IV
IDENTIFICATION OF ACTINIDES

λ	Multiplet	Number of Measurements	Source	Comments
AcI				
3843.04		2	SA	B
3885.56		2	SA	B
4179.88		2	SA	B
4194.40		2	SA	B
4462.73		2	SA	B
4613.93		3	SA	B
4705.77		3	SA	B
4716.58		3	SA	B
4860.16		3	SA	B
5258.24		1	SA	B
AcII				
3413.84		1	SA	B
3417.77		1	SA	B
3554.99		1	SA	B
3565.59		1	SA	B
3863.12		2	SA	B
3914.47		2	SA	B
4359.13		2	SA	B
4386.41		2	SA	B
4507.20		2	SA	B
4605.45		3	SA	B
4720.16		3	SA	B
4949.18		3	SA	B
58.23		3	SA	B
4960.87		3	SA	B
5910.85		3	SA	B

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ThI				
3413.99		1	JR	U
22.19		1	JR	U
23.99		1	N	U
3499.62		1	JR	B
3599.15		1	JR	B
3633.87		2	JR	B
3683.53		2	JR	B
3720.49		2	JR	B
43.99		2	JR	B
54.04		2	N	BB
3765.24		2	N	U
3803.07		2	N	CB
04.15		2	JR	B
98.43		2	N	BB
3898.50		2	N	BB
3932.91		2	N	B
3981.22		2	JR	B
4009.05		2	N	B
4060.40		2	JR	B
4157.27		2	N	B
57.39		2	N	B
4170.54		2	N	B
4214.83		2	N	U
4311.80		2	N	BB
4332.06		2	JR	U
4402.81		2	JR	BB
4493.33		2	N	B
4557.09		3	JR	B
4561.36		3	N	U

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ThI (Continued)				
4573.71		3	N	CB
4581.20		3	N	BB
4695.04		3	N	B
4705.31		3	JR	U
4723.78		3	N	B
4808.13		3	N	B
22.86		3	N	BB
4852.86		3	N	U
4927.78		3	N	BB
33.85		3	N	BB
36.77		3	N	BB
68.76		3	N	B
4970.06		3	N	U
5003.49		1	JR	U
5143.92		1	N	U
5163.46		1	N	U
5232.62		1	JR	U
5539.26		1	N	B
40.80		1	JR	B
48.18		1	N	B
5574.90		1	JR	B
5665.18		1	N	B
5725.39		1	N	BB
5940.47		1	JR	U
5994.16		1	N	CB
6037.70		1	N	BB
6327.28		1	N	BB
6376.93		1	N	U
6664.11		1	JR	U

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ThI (Continued)				
6733.76		1	N	BB
87.73		1	N	BB
6788.84		1	N	U
6836.81		1	JR	U
6911.23		1	N	CB
13.13		1	JR	B
43.61		1	N	CB
6945.53		1	JR	U
ThII				
3418.94		1	N	U
3494.52		1	JR	B
3537.15		1	N	B
3617.02		2	N	B
3617.10		2	N	CB
3760.28		2	N	BB
3805.81		2	N	B
3946.15		2	N	U
56.68		2	N	B
3988.60		2	N	B
4003.31		2	N	B
07.02		2	N	B
19.13	3	2	R	U
20.26		2	JR	B
4086.52		2	N	B
4116.71		2	N	B
48.18		2	N	B
78.06		2	N	B
4179.76		2	N	U
4229.45		2	N	CB

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ThII (Continued)				
4274.03		2	N	U
4281.41		2	N	CB
4328.68		2	N	B
4485.78		2	N	U
4511.79		2	JR	B
4575.27		3	N	U
4694.90		3	N	B
4705.76		3	N	B
4898.80		3	N	U
4929.98		3	N	BB
54.57		3	N	B
63.20		3	N	B
4964.12		3	N	B
5055.36		1	N	U
5189.68		1	N	BB
5190.88		1	N	U
5329.38		1	N	B
75.77		1	N	B
5390.46		1	N	B
5539.90		1	N	B
5641.31		1	JR	U
5654.01		1	N	B
5700.69		1	N	U
07.10		1	N	B
5749.40		1	N	B
5838.94		1	N	B
6015.43		1	N	BB
6200.43		1	N	U
6279.16		1	N	U

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ThII (Continued)				
6289.49		1	N	B
Th				
3607.91		1	N	U
3609.23		1	M	BB
3994.55		2	N	B
4401.99		2	M	U
6889.30		1	N	CB
PaII				
3430.89		1	JO	B
3480.98		1	JO	B
3626.68		2	JO	B
3777.39		2	JO	B
4035.06		2	JO	B
4129.09		2	JO	B
UI				
3489.37		1	N	CB
3514.61		1	N	BB
3566.60		1	N	BB
3584.88		1	N	B
3638.20		2	N	B
3659.16		2	N	B
3812.00		2	N	B
39.62		2	N	B
54.22		2	N	B
3871.04		2	N	B
3926.22		2	N	U
3943.82		2	N	B

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
UI (Continued)				
4042.76		2	N	U
4153.97		2	N	B
4556.87		3	N	B
4576.64		3	N	U
4928.44		3	N	BB
5496.43		1	N	B
5610.89		1	N	B
5736.38		1	N	B
5802.11		1	N	U
5971.50		1	N	U
6062.30		1	N	B
6620.52		1	N	BB
6826.93		1	N	BB
6832.71		1	N	BB
6915.31		1	N	U
6917.05		1	N	U
UII				
3670.07		2	N	B
3831.46		2	N	BB
54.66		2	N	U
59.58		2	N	B
3890.36		2	N	B
3902.49		2	N	B
04.56		2	N	U
15.88		2	N	U
53.88		2	N	B
54.56		2	N	CB
3990.42		2	N	B

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
UII (Continued)				
4004.06		2	N	BB
18.99		2	N	B
90.14		2	N	U
4098.03		2	N	B
4106.93		2	N	B
4155.41		2	N	CB
4241.67		2	N	B
4472.34		2	N	U
4567.69		3	N	U
69.91		3	N	BB
4573.69		3	N	CB
4646.60		3	N	B
4722.73		3	N	B
4858.08		3	N	CB
4859.68		3	N	B
4950.18		3	N	B
5278.18		3	N	B
U				
3914.20		2	N	CB
3914.27		2	N	CB
4128.34		2	N	B
4341.69		2	JR	U
4700.98		3	N	BB
4944.50		3	M	BB
5488.91		1	N	U
6028.13		1	N	U
6051.74		1	N	B
6132.61		1	N	U
6776.89		1	N	BB

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
U (Continued)				
6796.46		1	N	U
6869.07		1	N	CB
NpI				
3665.6		2	JO	U
3780.6		2	JO	B
3794.9		2	JO	B
3829.2		2	JO	B
32.3		2	JO	B
49.2		2	JO	B
53.2		2	JO	B
70.9		2	JO	B
3888.6		2	JO	B
3929.3		2	JO	B
49.2		2	JO	B
61.6		2	JO	U
67.4		2	JO	B
87.0		2	JO	B
3988.6		2	JO	B
4000.4		2	JO	B
15.5		2	JO	B
31.6		2	JO	B
4098.8		2	JO	B
4108.4		2	JO	B
23.3		2	JO	B
56.3		2	JO	B
64.5		2	JO	B
72.0		2	JO	B
4192.7		2	JO	B
4256.7		2	JO	U

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NpI (Continued)				
4269.6		2	JO	B
4281.4		2	JO	B
4333.9		2	JO	U
PuII				
3416.27		1	JENER	B
18.87		1	JENER	B
23.99		1	JENER	B
25.48		1	JENER	B
28.19		1	JENER	B
33.03		1	JENER	B
55.24		1	JENER	U
73.64		1	JENER	U
83.21		1	JENER	U
94.13		1	JENER	U
3498.64		1	JENER	B
3528.66		1	JENER	B
39.25		1	JENER	B
40.73		1	JENER	B
50.25		1	JENER	B
3590.13		1	JENER	U
3605.92		1	JENER	B
07.87		1	JENER	B
41.69		2	JENER	B
52.30		2	JENER	B
3690.39		2	JENER	B
3717.00		2	JENER	B
20.54		2	JENER	B
38.09		2	JENER	B
3751.11		2	JENER	U

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PuII (Continued)				
3770.31		2	JENER	B
3779.77		2	JENER	B
3805.83		2	JENER	B
14.19		2	JENER	B
23.92		2	JENER	B
31.01		2	JENER	B
38.91		2	JENER	B
3851.78		2	JENER	B
3958.90		2	JENER	B
79.86		2	JENER	U
85.47		2	JENER	B
3989.85		2	JENER	B
4002.63		2	JENER	B
04.70		2	JENER	B
10.63		2	JENER	B
13.17		2	JENER	U
15.90		2	JENER	B
21.51		2	JENER	B
24.63		2	JENER	U
4033.04		2	JENER	B
4104.42		2	JENER	B
07.17		2	JENER	B
4108.39		2	JENER	B
4278.79		2	JENER	B
4358.17		2	JENER	B
4448.30		2	JENER	U
4504.97		2	JENER	B
AmI				
3446.19		1	JO	U

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
AmI (Continued)				
3510.13		1	JO	U
30.95		1	JO	U
3569.16		1	JO	U
3603.41		1	JO	U
3673.12		2	JO	U
4020.25		2	JO	B
4289.26		2	JO	B
4329.83		2	JO	U
4370.76		2	JO	U
4637.51		3	JO	B
4681.65		3	JO	B
4853.04		3	JO	U
5000.21		1	JO	U
5920.51		1	JO	B
6115.23		1	JO	B
6298.79		1	JO	U
6299.36		1	JO	B
6566.82		1	JO	B
6955.58		1	JO	B
AmII				
3419.66		1	JO	B
39.78		1	JO	B
52.10		1	JO	U
3483.31		1	JO	U
3562.68		1	JO	B
66.78		1	JO	B
3596.07		1	JO	B
3777.50		2	JO	B
3926.25		2	JO	B

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
AmII (Continued)				
3952.58		2	JO	B
3976.71		2	JO	B
4036.36		2	JO	U
4089.29		2	JO	B
4324.57		2	JO	U
4445.36		2	JO	B
4493.98		2	JO	U
4575.59		3	JO	U
4600.39		3	JO	B
45.02		3	JO	B
4680.08		3	JO	B
4755.65		3	JO	U
4797.33		3	JO	U
4853.30		3	JO	B
4853.98		3	JO	U
5173.41		1	JO	U
CmII				
3417.29		1	JO	B
26.50		1	JO	B
38.23		1	JO	B
58.34		1	JO	B
82.52		1	JO	B
3487.79		1	JO	B
3510.28		1	JO	B
20.03		1	JO	B
46.14		1	JO	B
47.01		1	JO	B
50.29		1	JO	B
3570.43		1	JO	U

TABLE IV (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CmII (Continued)				
3573.67		1	JO	B
3591.48		1	JO	B
3692.30		2	JO	U
3900.26		2	JO	B
03.89		2	JO	B
19.35		2	JO	U
35.32		2	JO	B
60.29		2	JO	B
62.71		2	JO	B
3976.76		2	JO	B
4006.48		2	JO	U
24.58		2	JO	U
28.03		2	JO	B
4042.75		2	JO	B
4129.11		2	JO	B
57.47		2	JO	B
64.45		2	JO	B
4177.49		2	JO	B
4207.66		2	JO	B
18.46		2	JO	B
36.30		2	JO	B
4240.14		2	JO	B
4357.10		2	JO	U
4402.52		2	JO	B
02.95		2	JO	U
29.51		2	JO	U
4494.27		2	JO	B
4547.27		2	JO	B
4717.65		2	JO	B

TABLE IV (Concluded)

λ	Multiplet	Number of Measurements	Source	Comments
BkII				
3412.01		1	JO	U
3496.13		1	JO	B
3603.25		1	JO	B
3673.09		2	JO	U
3681.25		2	JO	U
3711.18		2	JO	U
25.55		2	JO	B
3752.66		2	JO	B
3916.24		2	JO	B
EsII				
3547.72		1	JO	B
3602.42		1	JO	B
3728.39		2	JO	B
3936.96		2	JO	B
3988.28		2	JO	B

TABLE V
IDENTIFICATION OF OTHER ELEMENTS OF INTEREST

λ	Multiplet	Number of Measurements	Source	Comments
CI				
4766.62	6	3	R	B
4817.33	5	3	R	B
4932.00	13	3	R	B
5041.66	4	1	R	U
5380.24	11	1	R	U
CII				
3968.94	18	2	R	U
3980.35	37	2	R	U
4727.21	48	3	R	B
4959.52	25	3	R	U
4964.90	25	3	R	B
5121.65	12	1	R	B
37.26	16	1	R	B
5145.16	16	1	R	B
5249.43	30	1	R	B
5253.55	30	1	R	B
5817.87	22	1	R	B
5836.31	22	1	R	U
5907.36	44	1	R	B
6115.21	19	1	R	U
6783.85	14	1	R	U
87.09	14	1	R	BB
6791.30	14	1	R	U
NeI				
5005.16	29	1	R	U
5037.75	14	1	R	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NeI (Continued)				
5330.78	9	1	R	U
43.28	9	1	R	B
60.44		1	N	U
5366.22		1	M	U
5412.65		1	M	B
5820.15	19	1	R	B
5974.63	28	1	R	B
6929.47	6	1	R	BB
AlI				
3944.03	1	2	R	B
3961.53	1	2	R	U
SiI				
4321.81		2	M	B
4338.57		2	M	U
4949.72		3	M	BB
5690.47	10	1	R	U
5708.44	10	1	R	B
5793.13	9	1	R	U
6124.85	30	1	R	B
31.86	30	1	R	BB
45.08	29	1	R	U
55.22	29	1	R	B
6155.73	29	1	R	U
6243.86	28	1	R	U
54.25	28	1	R	U
6255.60		1	M	U
6560.68	62	1	R	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SiI (Continued)				
6721.97	Unclassified	1	R	U
6842.35	61	1	R	U
SiII				
3991.77	Unclassified	2	R	B
5540.74	9	1	R	U
5806.75	8	1	R	B
5948.58	16	1	R	U
57.61	4	1	R	B
5978.97	4	1	R	U
6347.09	2	1	R	U
6371.36	2	1	R	U
AlI				
6638.24	20	1	R	U
6639.72	20	1	R	B
6808.55	24	1	R	U
ScI				
3419.36	21	1	R	U
29.48	21	1	R	U
3498.91		1	N	BB
3907.48	8	2	R	B
4020.40	7	2	R	U
30.67		2	N	B
31.39		2	N	B
47.79	7	2	R	U
4087.16		2	N	U
4389.60		2	N	U
4557.24	Unclassified	3	R	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ScI (Continued)				
4573.99	Unclassified	3	R	CB
92.94		3	N	B
4598.45		3	N	U
4729.23	14	3	R	U
34.10	14	3	R	BB
41.02	14	3	R	U
4779.35	5	3	R	B
4934.25		3	N	CB
4954.06		3	N	B
5021.51		1	N	B
5083.71	13	1	R	BB
5258.33	23	1	R	U
5339.41		1	N	B
5341.05		1	N	B
5484.62	16	1	R	U
5546.40		1	N	B
64.86	18	1	R	U
79.76		1	N	B
5591.33	18	1	R	B
5724.07	12	1	R	U
5741.36	12	1	R	BB
6036.17	Unclassified	1	R	U
6239.78		1	N	B
6262.25		1	N	BB
6737.87	Unclassified	1	R	BB
6819.52		1	N	U
ScII				
3576.34	3	1	R	B
3580.93	3	1	R	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ScII (Continued)				
3589.64	3	1	R	B
3590.48	3	1	R	U
3613.84	2	2	R	U
3989.06	8	2	R	U
4008.41	16	2	R	U
4305.72	15	2	R	U
4670.40	24	3	R	B
5031.02	23	1	R	U
5068.86		1	N	B
5133.68		1	N	B
5239.82	26	1	R	B
5357.19	30	1	R	B
5526.81	31	1	R	U
5552.25	25	1	R	B
5684.20	29	1	R	U
5806.77	21	1	R	B
6001.53	20	1	R	U
6309.90	28	1	R	U
Sc				
4237.82		2	N	BB
4771.44		3	N	U
4858.09		3	N	B
5032.74		1	N	B
5109.06		1	N	B
5847.73		1	N	B
6188.09		1	N	BB
6525.62		1	N	U
6566.88		1	N	BB
6705.93		1	N	BB

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CuI				
5218.20	7	1	R	B
6881.94		1	M	U
6920.06		1	M	U
CuII				
4812.94	8	3	R	B
4931.48		3	M	BB
31.65	5	3	R	BB
37.20	6	3	R	B
4937.97		3	M	B
5006.79	10	1	R	U
60.64	1	1	R	BB
65.45	11	1	R	BB
67.08	7	1	R	B
5088.26	6	1	R	U
GaI				
4172.06	1	2	R	B
4559.62		3	N	CB
GaII				
4251.15		2	N	U
SeI				
6283.96		1	M	BB
SeII				
4401.02		2	M	U
6541.23		1	M	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SrI				
4030.38		2	N	B
4722.28	5	3	R	U
4832.08	4,5	3	R	U
72.49	4	3	R	B
4876.06	4	3	R	U
4962.26	4	3	R	CB
67.94	4	3	R	B
4971.67	4	3	R	U
5256.90		1	N	U
5480.87	9	1	R	CB
5486.14	9	1	R	U
5521.76	9	1	R	U
5534.81	9	1	R	B
6380.75		1	N	B
6386.50		1	N	U
6550.26	12	1	R	BB
6617.27	12	1	R	BB
6878.31	3	1	R	U
6892.58	1	1	R	CB
SrII				
3464.46	4	1	R	U
3474.89	4	1	R	U
4161.80	3	2	R	U
NbI				
3697.39		2	N	B
3795.54		2	N	U
3877.56		2	N	U
3935.45		2	N	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NbI				
4009.71		2	N	B
12.06		2	N	U
27.98		2	N	U
29.22		2	N	B
79.73	1	2	R	B
4084.18		2	N	B
4100.40		2	N	BB
06.18		2	N	B
39.44		2	N	B
39.71	1	2	R	U
47.19		2	N	B
64.66	1	2	R	U
65.85		2	N	U
68.13	1	2	R	BB
79.76		2	N	BB
4195.66		2	N	B
4201.52		2	N	B
4573.08		3	N	BB
74.84		3	N	U
4575.37		3	N	BB
4627.48		3	N	B
30.11		3	N	B
48.95		3	N	B
4685.14		3	N	U
4730.31		3	N	BB
49.70		3	N	CB
4777.61		3	N	U
4816.38		3	N	CB
4842.15		3	N	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
NbI (Continued)				
4895.58		3	N	B
4928.98		3	N	U
67.78		3	N	BB
71.93		3	N	B
73.14		3	N	CB
4975.14		3	N	B
5017.75		1	N	U
5078.96		1	N	B
5285.26		1	N	U
5336.81		1	N	B
5355.31		1	N	CB
5448.31		1	N	B
5499.53		1	N	B
5571.44		1	N	U
5642.11		1	N	BB
5874.70		1	N	BB
6660.84		1	N	BB
6677.33		1	N	B
6795.31		1	N	BB
6946.07		1	N	B
NbII				
3425.42	7	1	R	U
3426.57	7	1	R	U
3863.05	9	2	R	U
3898.29	9	2	R	B
4579.45	8	3	R	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Nb				
3528.48		1	M	U
4569.16		3	M	U
4569.48		3	M	B
4936.71		3	M	BB
4976.77		3	M	U
5578.06		1	M	U
6940.90		1	M	B
6948.72		1	M	U
MoI				
3424.76		1	N	B
3595.55		1	N	U
3781.60	8	2	R	B
3902.96	1	2	R	U
3986.20		2	N	B
4028.65		2	N	U
56.32		2	N	B
4096.81		2	N	B
4211.02		2	N	U
4366.54		2	N	B
4411.70		2	N	U
4426.67		2	N	U
4504.90		2	N	CB
12.15		2	N	B
4558.11		3	N	CB
4608.71		3	N	B
09.88		3	N	B
21.38		3	N	U
4623.46		3	N	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
MoI (Continued)				
4624.24		3	N	U
27.48		3	N	B
61.93	6	3	R	B
4686.10		3	N	U
4706.06		3	N	U
07.26		3	N	U
58.50		3	N	U
74.22		3	N	BB
76.34		3	N	B
4785.12		3	N	B
4819.25		3	N	B
30.51		3	N	BB
33.96		3	N	U
4858.22		3	N	B
4926.19		3	N	BB
33.10		3	N	B
41.66		3	N	BB
64.19		3	N	B
4979.12		3	N	U
5029.00		1	N	CB
5046.52		1	N	BB
5109.71		1	N	B
5259.04		1	N	B
60.17		1	N	U
5295.47		1	N	U
5356.48		1	N	B
5439.71		1	N	U
5498.49		1	N	U
5520.64		1	N	BB
5570.45	4	1	R	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
MoI (Continued)				
5610.93		1	N	B
64.34		1	N	B
5664.38		1	N	B
5723.11		1	N	BB
41.71		1	N	BB
5778.19		1	N	BB
5848.86		1	N	B
5851.52		1	N	U
6025.49		1	N	B
6030.66	5	1	R	U
6217.89		1	N	BB
6357.22		1	N	B
6590.90		1	N	BB
6659.68		1	N	U
6799.88		1	N	U
6829.05		1	N	CB
86.28		1	N	U
6892.36		1	N	CB
6914.01		1	N	CB
31.40		1	N	U
6946.75		1	N	U
Mo				
4192.29		2	M	U
4219.02		2	M	U
4453.87		2	M	CB
4927.05		3	M	BB
31.15		3	M	B
33.33		3	M	B
4933.46		3	M	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Mo (Continued)				
4933.73		3	M	BB
53.79		3	M	B
4956.58		3	M	BB
5053.59		1	M	U
5261.57		1	M	U
5893.74		1	M	U
6213.25		1	M	U
6957.03		1	M	U
TcI				
3475.60		1	JR	B
3549.74		1	JR	BB
50.66		1	JR	B
60.34		1	JR	B
68.87		1	JR	B
81.27		1	JR	B
82.66		1	JR	B
3587.96		1	JR	BB
3635.18		2	JR	B
40.23		2	JR	BB
48.06		2	JR	BB
3679.18		2	JR	U
3718.88		2	JR	B
26.36		2	JR	U
79.40		2	JR	B
3780.70		2	JR	B
3845.99		2	JR	B
47.35		2	JR	U
3892.14		2	JR	B
3984.97		2	JR	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TcI (Continued)				
3994.51		2	JR	B
4031.63		2	JR	B
4100.08		2	JR	U
45.02		2	JR	B
4165.62		2	JR	B
4262.26		2	JR	B
62.67		2	JR	B
4297.06		2	JR	B
4630.57		3	JR	B
37.51		3	JR	B
48.34		3	JR	BB
4669.30		3	JR	U
4719.28		3	JR	BB
4771.53		3	JR	B
4800.62		3	JR	BB
20.75		3	JR	U
34.36		3	JR	CB
53.57		3	JR	B
62.91		3	JR	U
4891.89		3	JR	BB
4938.79		3	JR	B
56.32		3	JR	U
4976.34		3	JR	B
5174.79		1	JR	U
5642.12		1	JR	B
5924.47		1	JR	B
6099.38		1	JR	B
6192.65		1	JR	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
	RuI			
3428.31		1	N	U
3717.00		2	N	U
3728.03	2	2	R	U
3860.72		2	N	B
4107.84		2	N	U
48.38		2	N	B
4159.17		2	N	B
4278.69		2	N	B
4554.51	5	3	R	U
84.45	6	3	R	U
4599.08		3	N	B
4645.09		3	N	U
4690.11		3	N	B
4757.84	12	3	R	B
69.30		3	N	U
4795.57		3	N	B
4839.01		3	N	BB
39.76		3	N	BB
44.56		3	N	U
4895.60		3	N	B
4938.43		3	N	BB
55.24		3	N	U
59.86		3	N	BB
68.90		3	N	U
74.12		3	N	BB
4976.20		3	N	BB
5028.16		1	N	B
5057.33		1	N	U
5155.14	10	1	R	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
RuI (Continued)				
5284.08		1	N	B
5332.93		1	N	B
5335.93		1	N	B
5475.18		1	N	BB
79.40		1	N	U
5496.69		1	N	BB
5510.71		1	N	B
5665.20		1	N	B
5756.83		1	N	B
5921.45		1	N	U
6718.30		1	N	U
6805.54		1	N	BB
6831.52		1	N	BB
6923.23		1	N	U
Ru				
3562.62		1	M	B
4570.25		3	M	CB
4593.03		3	M	B
4681.39		3	M	U
6872.95		1	M	CB
6934.86		1	M	CB
RhI				
3583.10	3	1	R	BB
3793.22	9	2	R	BB
3822.26	8	2	R	BB
3958.86	7	2	R	U
4097.52		2	N	B
4963.70		3	N	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
RhI (Continued)				
5356.47		1	N	B
5379.10		1	N	B
5468.11		1	N	B
5726.68		1	M	U
5983.60		1	N	B
6290.39		1	M	U
6752.35		1	N	U
Rh				
4851.63		3	N	BB
5730.43		1	M	U
PdI				
3553.10	9	1	R	U
3571.16	1	1	R	U
3634.70		2	N	B
3690.35	7	2	R	U
4087.34		2	N	B
5687.49		1	M	U
6774.54		1	N	BB
6784.52		1	M	BB
CdI				
3612.88		2	N	B
4678.16	2	3	R	U
4799.92	2	3	R	B
5085.82	2	1	R	B
CdII				
3535.69		1	N	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
InII				
6096.11		1	M	U
6228.53		1	M	BB
6541.22		1	M	B
6891.63		1	M	BB
91.66		1	M	BB
6891.99		1	M	U
XeI				
5460.04		1	M	B
6469.70		1	M	B
6559.97		1	M	U
6681.04		1	M	B
6866.84		1	M	U
6924.67		1	M	U
25.53		1	M	CB
35.62		1	M	U
6936.69		1	M	U
XeII				
4773.19		3	M	U
5659.38		1	M	U
5945.53		1	M	U
5958.03		1	M	B
6093.56		1	M	U
CsI				
4555.42	2	3	R	CB
4593.20	2	3	R	U
5663.8		1	N	U
6723.28		1	N	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CsI (Continued)				
6825.22		1	M	BB
6870.45		1	M	U
BaI				
3501.11		1	N	U
3909.91	8	2	R	B
4332.91		2	M	BB
4431.89		2	N	B
4505.92		2	N	U
4573.85		3	N	B
4947.33		3	N	BB
5267.03		1	N	B
5535.48	2	1	R	U
5680.18		1	N	U
5805.68		1	N	BB
5826.28		1	N	B
5997.08	7	1	R	CB
6063.12	7	1	R	B
6110.78	7	1	R	BB
6496.90	2	1	R	U
6865.69		1	N	BB
6932.92		1	M	CB
BaII				
3891.78	4	2	R	B
4405.23	16	2	R	B
4524.93	3	2	R	U
4554.03	1	3	R	U
4899.93	3	3	R	B
4934.09	1	3	R	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
BaII (Continued)				
5428.79	9	1	R	B
5853.68	2	1	R	U
5981.25	13	1	R	B
6141.72	2	1	R	U
LaI				
3641.53		2	N	BB
3898.60		2	N	U
4192.73		2	M	U
4537.58		3	M	CB
4570.02	11	3	R	U
4702.64		3	N	BB
50.41		3	N	B
4770.43		3	N	BB
4800.00		3	N	B
50.82		3	N	U
4878.86		3	N	U
4945.85		3	N	BB
4949.77	4	3	R	BB
5106.23	9	1	R	B
5177.30	9	1	R	B
5257.85		1	N	U
5357.86		1	N	B
5475.17		1	N	BB
5565.72		1	N	B
5657.72		1	N	U
5744.41		1	N	U
5769.99		1	N	U
5821.98		1	N	B
5852.27		1	N	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
LaI (Continued)				
5869.95		1	N	U
5877.99		1	N	CB
5960.59		1	N	U
62.60		1	N	U
5982.35		1	N	CB
6038.61		1	M	B
6084.89		1	N	BB
6218.20		1	N	BB
33.51		1	N	B
49.93	7	1	R	U
66.02		1	N	BB
6287.74		1	N	U
6333.21		1	M	BB
6506.23		1	N	U
6600.17		1	N	BB
08.26		1	N	U
6650.81		1	N	BB
6823.78		1	N	U
6935.01		1	N	CB
LaII				
3609.23		1	N	B
10.25	Unclassified	1	R	U
3612.34	125	1	R	U
3701.81	136	2	R	U
3713.54	26	2	R	BB
3929.22	27	2	R	U
62.03	Unclassified	2	R	B
3988.52	40	2	R	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
LaII (Continued)				
4031.69	40	2	R	U
4123.23	41	2	R	U
32.50	150	2	R	B
41.74	40	2	R	B
51.97	40	2	R	B
94.36	160	2	R	CB
4196.55	41	2	R	U
4230.95		2	N	U
4322.51	25	2	R	BB
4333.74	24	2	R	U
4429.90	38	2	R	B
4498.76	94	2	R	B
4574.87	23	3	R	B
4613.38	50	3	R	B
68.91	76	3	R	U
4692.50	75	3	R	BB
4717.58	87	3	R	B
24.43	50	3	R	B
28.42	22	3	R	B
40.28	8	3	R	U
4743.09	75	3	R	U
4809.01	37	3	R	U
40.01	37	3	R	B
50.58	51,88	3	R	CB
60.90	8	3	R	BB
4899.92	7	3	R	B
4921.79	7	3	R	B
34.83	72	3	R	U
35.62	50	3	R	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
LaII (Continued)				
4946.47	36	3	R	U
70.39	37	3	R	B
86.83	22	3	R	B
91.27	57	3	R	B
4999.47	37	3	R	CB
5122.99	36	1	R	BB
5156.74	7	1	R	B
5290.83	6	1	R	U
5303.54	36	1	R	U
5380.99	56	1	R	B
5482.27	4	1	R	B
5671.54	95	1	R	B
5703.32	48	1	R	B
27.29	48	1	R	B
69.06	70	1	R	B
81.02		1	M	U
5797.58	4	1	R	B
5808.31	4	1	R	BB
48.95	111	1	R	B
74.00	48	1	R	U
80.64	35	1	R	U
5892.66	48	1	R	B
5927.71	111	1	R	B
5936.22	19	1	R	U
6188.09	111	1	R	BB
6203.51	111	1	R	BB
6296.08	47,68	1	R	U
6320.39	19	1	R	U
6374.08	111	1	R	BB

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
LaII (Continued)				
6390.48	33	1	R	BB
6732.80	109	1	R	BB
6774.26	2	1	R	BB
6830.83	108	1	R	BB
6952.52	18	1	R	U
54.52	1	1	R	CB
6958.10	67	1	R	B
HfI				
3419.18		1	N	U
3427.44		1	N	B
3616.89		2	N	BB
3830.02		2	N	B
4174.34	3	2	R	B
4223.54		2	N	CB
4318.14		2	N	B
56.33		2	N	U
4356.99		2	N	U
4416.19		2	N	U
4495.83		2	N	U
4504.33		2	N	U
4540.93		3	N	B
4630.61		3	N	U
4773.72		3	N	BB
4818.87		3	N	U
50.61		3	N	BB
59.24		3	N	B
72.94		3	N	B
4877.58		3	N	B
4948.94		3	N	BB

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
HfI (Continued)				
5552.12	7	1	R	B
5933.69		1	N	B
6556.50		1	N	U
6769.95		1	N	B
HfII				
3421.42		1	N	U
3495.75	10	1	R	B
3622.46		2	M	B
3880.82		2	N	U
3923.90	18	2	R	U
46.00	115	2	R	B
64.96	54	2	R	B
3984.03	19	2	R	B
4020.25	40	2	R	U
29.16	23	2	R	B
50.67	59	2	R	B
80.44	6	2	R	B
4093.16	6	2	R	U
4127.80	41	2	R	B
4141.84	87	2	R	B
4218.84		2	M	B
4232.44	72	2	R	B
4519.02	Unclassified	2	R	U
24.74	104	2	R	U
33.18	25	3	R	U
35.38	72	3	R	CB
4599.46	92	3	R	B
4703.62	72	3	R	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
HfII (Continued)				
4719.10	15	3	R	B
35.75	59	3	R	B
4760.59	85	3	R	BB
4817.21	69	3	R	B
4834.84		3	M	B
4934.45	16	3	R	U
4945.38	15	3	R	B
5080.44	83	1	R	B
5324.26	14	1	R	U
5391.36	48	1	R	B
5444.07	69	1	R	B
5524.35	25	1	R	BB
5565.56	100	1	R	B
5809.50	14	1	R	U
5842.23	50	1	R	U
5969.38	66	1	R	U
6222.81	57	1	R	B
6248.95	22	1	R	B
6511.62	69	1	R	BB
6754.61	35	1	R	BB
6769.95		1	N	BB
6835.29	13	1	R	U
6850.07	Unclassified	1	R	U
TaI				
3424.45		1	N	U
3430.94		1	N	B
3576.72		1	N	B
3936.55		2	N	U

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TaI (Continued)				
3970.10	1	2	R	B
4061.40		2	N	U
4175.21		2	N	B
4205.88		2	N	B
4376.43		2	N	B
4424.96		2	N	U
4521.71		2	N	BB
59.46		3	N	CB
61.48		3	N	B
66.86		3	N	B
73.29		3	N	U
74.32	1	3	R	U
4580.69		3	N	B
4601.42		3	N	U
04.28		3	N	B
19.51		3	N	U
81.88		3	N	B
4691.90		3	N	B
4730.12		3	N	B
56.51		3	N	B
4780.94		3	N	U
4819.53		3	N	B
4852.17		3	N	BB
4924.96		3	N	U
36.42	11	3	R	B
4976.20		3	N	BB
5043.32		1	N	U
5082.25		1	N	B
5109.77		1	N	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
TaI (Continued)				
5147.62		1	N	BB
5156.56		1	N	B
5341.05		1	N	B
5373.01		1	N	B
5461.29	4	1	R	BB
5640.18		1	N	U
6047.25		1	N	U
6092.06		1	N	B
6152.54		1	N	B
6289.34		1	N	B
6430.78	11	1	R	B
6516.10		1	N	B
6574.84		1	N	B
6611.95		1	N	B
73.73		1	N	BB
6675.53		1	N	U
6740.73		1	N	BB
6813.25		1	N	BB
6850.83		1	N	BB
6902.10		1	N	B
27.38		1	N	BB
28.54		1	N	BB
51.26		1	N	CB
6953.88		1	N	BB
Ta				
4338.20		2	M	U
6018.97		1	M	U
6092.95		1	M	BB
6669.11		1	M	BB

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
	Wi			
3682.10	4	2	R	B
3792.77		2	N	U
3829.13	3	2	R	BB
35.06	2	2	R	BB
43.83	1	2	R	B
64.34	3	2	R	BB
3872.84	4	2	R	B
3983.29		2	N	B
4008.75		2	N	B
69.95		2	N	B
74.36	6	2	R	B
4082.97		2	N	B
4160.35		2	N	B
4170.54		2	N	B
4244.37	1	2	R	B
4302.12	7	2	R	B
4493.97		2	N	B
4534.71		3	N	U
43.51		3	N	U
57.57	7	3	R	BB
70.06		3	N	B
79.70		3	N	BB
86.85		3	N	U
4588.75		3	N	B
4659.87		3	N	U
77.69		3	N	BB
4680.52		3	N	B
4729.65		3	N	B
4757.57	7	3	R	CB

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
WI (Continued)				
4843.83	1	3	R	BB
4854.09		3	N	B
4931.56		3	N	BB
5052.23		1	N	U
54.61		1	N	B
5069.15		1	N	B
5357.12		1	N	B
5388.02		1	N	U
5492.32		1	N	B
5508.63		1	N	B
5723.06		1	N	BB
5796.51		1	N	U
5838.99		1	N	B
6934.27		1	N	CB
W				
4476.54		2	M	B
4542.89		3	M	U
4926.71		3	M	BB
4932.79		3	M	BB
5554.11		1	M	BB
5631.83		1	M	B
5654.10		1	M	B
6037.33		1	M	U
ReI				
3419.41		1	N	B
3945.91		2	N	B
4477.99		2	N	U
4513.31		2	N	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
ReI (Continued)				
4586.85		3	N	U
4758.83		3	N	U
4889.15	1	3	R	B
4923.90		3	N	B
46.72		3	N	B
4956.76		3	N	U
5270.95		1	N	U
5321.28		1	N	B
5919.86		1	N	U
6307.70		1	N	BB
6577.11		1	N	BB
6605.19		1	N	U
6829.90		1	N	B
Re				
5580.79		1	M	U
5740.30		1	M	B
OsI				
3427.44		1	N	B
3542.71		1	N	U
3640.33		2	N	CB
3706.56		2	N	BB
20.13		2	N	BB
3746.47		2	N	B
3901.71		2	N	U
3988.18		2	N	B
4048.05		2	N	B
4091.82		2	N	U
4112.02	5	2	R	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
OsI (Continued)				
4135.78	3	2	R	B
4158.78		2	N	B
4285.90		2	N	BB
4328.68		2	N	B
4338.75		2	N	B
4548.66		3	N	CB
50.41		3	N	B
95.04		3	N	B
4597.16		3	N	CB
4634.77		3	N	B
4793.99		3	N	U
4813.80		3	N	B
15.50		3	N	CB
15.96		3	N	BB
4826.66		3	N	B
4935.81		3	N	B
5193.52		3	N	B
5302.58		1	N	U
5376.79		1	N	B
5443.31		1	N	B
5552.88		1	N	BB
5645.25		1	N	U
5860.64		1	N	U
6158.03		1	N	U
6878.70		1	N	B
6901.58		1	N	B
Os				
3583.09		1	N	U
3760.27		2	N	B

TABLE V (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
Os (Continued)				
4567.48		3	M	U
4849.22		3	M	CB
IrI				
3747.20		2	N	U
3992.11	5	2	R	B
4069.92		2	N	B
4568.09		3	N	B
4581.92		3	M	U
4938.09		3	N	CB
PtI				
3638.80	6	2	R	CB
4164.54	6	2	R	U
4411.40		2	M	CB
4498.76		2	N	B
4577.42		3	M	U
5059.48		3	N	U
6026.04		3	N	U
6710.42		3	N	B
AuI				
4065.08	3	2	R	B
4811.61	3	3	R	U
5064.49	1	1	R	B
5837.29	2	1	R	U
6278.30	1	1	R	U
HgI				
4358.34	1	2	R	B
6888.74		1	M	CB

TABLE V (Concluded)

λ	Multiplet	Number of Measurements	Source	Comments
HgII				
5425.25		1	M	B
5677.17		1	M	U
5888.94		1	M	U
PbI				
3683.47	1	2	R	BB
4057.83	1	2	R	U
4062.14		2	N	B
BiI				
4121.53		2	N	B

TABLE VI
IDENTIFICATION OF THE DOUBLY IONIZED LANTHANIDES

λ	Multiplet	Number of Measurements	Source	Comments
LaIII				
3517.09		1	JO	U
3517.22		1	JO	B
4482.97		2	JO	B
4499.05		2	JO	B
5778.14		1	JO	U
CeIII				
3412.01		1	JO	B
27.36	2	1	R	U
43.63	1	1	R	B
54.39	3	1	R	B
59.39	1	1	R	B
70.92		1	JO	U
92.52		1	JO	B
3497.81		1	JO	B
3504.64	6	1	R	U
14.41		1	JO	B
3544.07		1	JO	U
3645.22		2	JO	U
3784.29		2	JO	B
3906.79		2	JO	B
3936.80		2	JO	U
4336.95		2	JO	U
4424.97		2	JO	B
40.12		2	JO	U
4448.32		2	JO	U
4521.92		2	JO	U

TABLE VI (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
CeIII (Continued)				
4535.73		3	JO	B
4576.90		3	JO	U
4632.83		3	JO	B
4766.07		3	JO	U
4885.73		3	JO	B
4976.45		3	JO	U
5749.47		1	JO	B
6002.63		1	JO	B
6287.79		1	JO	B
6944.93		1	JO	B
PrIII				
3413.21		1	JR	U
15.06		1	JR	U
15.11		1	JR	U
15.15		1	JR	U
19.86		1	JR	B
20.07		1	JR	U
22.22		1	JR	U
22.36		1	JR	U
27.02		1	JR	U
36.36		1	JR	U
36.40		1	JR	U
40.62		1	JR	B
40.71		1	JR	U
52.96		1	JR	U
53.01		1	JR	B
54.01		1	JR	B
3454.05		1	JR	B
3522.08		1	JR	U

TABLE VI (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PrIII (Continued)				
3564.01		1	JR	B
3653.58		2	JR	B
3980.51		2	JR	B
4000.20		2	JR	B
4029.60		2	JR	B
4144.48		2	JR	B
84.18		2	JR	B
4197.01		2	JR	B
4231.45		2	JR	B
75.07		2	JR	B
4286.32		2	JR	B
4404.71		2	JR	B
50.14		2	JR	B
4461.81		2	JR	B
4500.31		2	JR	B
35.13		3	JR	B
4577.88		3	JR	B
4612.02		3	JR	B
4625.18		3	JR	B
4725.55		3	JR	B
47.11		3	JR	B
71.83		3	JR	B
4775.30		3	JR	B
4845.32		3	JR	U
4929.12		3	JR	U
5174.71		1	JR	U
5261.68		1	JR	U
5299.99		1	JR	B
5646.80		1	JR	U

TABLE VI (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
PrIII (Continued)				
5844.41		1	JR	B
5956.05		1	JR	U
6090.02		1	JR	U
99.40		1	JR	B
99.54		1	JR	B
6099.66		1	JR	B
6160.24		1	JR	B
6460.60		1	JR	U
6501.49		1	JR	B
NdIII				
3442.78		1	A	U
3590.33		1	A	U
3597.63		1	A	B
3603.98		1	A	B
3612.34		1	A	B
3621.17		2	A	B
4624.96		3	A	B
4765.26		3	A	U
SmIII				
3414.48		1	A	U
33.60		1	A	U
53.21		1	A	B
3482.57		1	A	B
3517.03		1	A	U
28.77		1	A	U
31.59		1	A	B
36.17		1	A	B
3580.51		1	A	B

TABLE VI (Continued)

λ	Multiplet	Number of Measurements	Source	Comments
SmIII (Continued)				
3593.42		1	A	B
3618.39		2	A	B
55.33		2	A	B
3693.43		2	A	B
3724.23		2	A	U
3739.20		2	A	B
4032.60		2	A	B
TbIII				
3528.50		1	A	B
3578.38		1	A	B
3754.81		2	A	U
3961.75		2	A	U
4002.89		2	A	B
4012.17		2	A	B
4164.71		2	A	U
4449.32		2	A	B
4467.32		2	A	B
4521.65		2	A	U
4620.95		3	A	U
4695.71		3	A	B
4774.12		3	A	B
4775.46		3	A	B
4842.85		3	A	B
4921.84		3	A	B
5024.61		1	A	B
5318.73		1	A	B
25.80		1	A	B
5330.01		1	A	B
5758.63		1	A	U

TABLE VI (Concluded)

λ	Multiplet	Number of Measurements	Source	Comments
TbIII (Continued)				
6092.90		1	A	B
6442.87		1	A	U
6687.70		1	A	U
6716.50		1	A	U
ErIII				
3816.78		2	A	B
4290.06		2	A	B
4386.85		2	A	B
4735.36		3	A	B
35.56		3	A	B
4783.12		3	A	B

CHAPTER IV

SUMMARY AND CONCLUSIONS

Line identification for the rare earths in this thesis have given support to data already obtained by other investigators (Brandt and Jaschek 1970; Hardorp and Shore 1971; Hartoog and Cowley 1972; Adelman and Shore 1973).

Without a doubt some of the lines measured from the tracings are quite questionable, as stated under comments in the previous tables. However, it is this author's opinion that some of the identifications in question do in fact warrant some credibility.

Until the work of Adelman, et al (1973), no previous attempts to identify the doubly ionized rare earths in Beta Coronae Borealis have been reported in the literature. Adelman's (1974) unpublished selected line list of the ultraviolet region of γ Equ contained several CeIII, PrIII, SmIII, and NdIII lines. These lines have also been identified in Beta Coronae Borealis by Adelman, et al (1973). It is with great excitement that the author would like to confirm lines due to the aforementioned rare earths while, in addition, several lines due to LaIII, TbIII, ErIII, and YbIII have also been tentatively identified.

Each of these ionic identifications is based primarily on only a few unblended lines while blends contribute additional support to their identifications.

Recent studies of the spectra of cooler magnetic Ap stars have indicated probable identification of the lines of singly ionized uranium (Brandt and Jaschek 1970; Hardorp and Shore 1971; Hartoog and Cowley 1972; Adelman 1973). These identifications are also confirmed. The strongest lines of UII have been identified with some certainty while others were found in blends. The strongest lines of ThII have also been tentatively identified in this star while still others are definitely due to blends. Several of the weaker ThII lines have some uncertainty. However, identification is probable since the half-life of Th^{232} is on the order of 1.39×10^{10} years.

It is also interesting to note that several lines due to neutral uranium and thorium have been measured. Only a few though are due to the strongest lines of UI and ThI. Many other weak features have been tentatively identified for UI and ThI.

Some of the other transuranium lines have also been measured. Several lines have wavelengths corresponding to neptunium lines. It is possible for this element to be present since Np^{237} , the longest lived isotope, has a half-life of about 2.2×10^6 years. However, the data in the literature at present are not satisfactory enough for a definitive identification of this element. Even though the lines are reported the results are inconclusive at this time. Other lines had wavelengths which corresponded to several plutonium lines. Pu^{244} with a half-life of 8.0×10^7 years would make for a probable identification. Several other lines which might be associated with a few curium lines have also been measured. Again these are classified as very probable identifications since Cm^{247} has a half-life of $\geq 4.0 \times 10^7$ years. The lines that have been associated with

AmI and AmII appear to be an unlikely identification (the half-life of Am^{243} is about 7.95×10^3 years). Since the longest lived isotope of einsteinium has a half-life of about 480 days, it is very unlikely that this superheavy element is present in this star.

Although considerable work has been done on the spectrum of Beta Coronae Borealis since the fundamental line identifications by Hiltner (1945) of the region $\lambda\lambda 3980-4638$ and later by J. Gruber (1972) of Oklahoma State University who extended this region to $\lambda\lambda 3613-4863$, there are still many lines present in this peculiar star that remain unidentified.

Most of the identifications of the singly ionized rare earths are in good agreement with those of Hiltner and those of the doubly ionized rare earths are in good agreement with those of Adelman and Shore and Tiernan (1973).

The following is a summary of the elements identified in Beta Coronae Borealis in the order of increasing atomic number. Out of approximately 6700 lines measured only 3719 were considered for this paper.

Carbon:

There were five CI lines and seventeen CII lines identified. It is very reasonable that these lines are indeed present.

Neon:

A search for Neon in other Ap stars has been quite successful, and it is very probable that NeI is present in Beta Coronae Borealis. There were eleven lines measured whose wavelengths were very close to those of NeI lines.

Aluminum:

Only two lines of AlI have been identified. The two strongest lines of AlI were definitely present.

Silicon:

There were seventeen SiI lines and eight SiII lines which have not been reported thusfar.

Argon:

Three lines of AII were identified.

Scandium:

There were thirty-seven ScI lines, twenty ScII lines, and ten lines of Sc which did not have any ionization state designation.

Copper:

There were only three CuI and ten CuII lines reported here.

Gallium:

The two strongest lines of GaI and one of GaII were present. There is indeed a strong indication that this element is present.

Selenium:

Only one line of SeI was measured in this spectral region. Two SeII lines were measured and recorded.

Strontium:

There were nineteen SrI lines and three SrII lines measured. This star has the characteristics of the enhanced strontium lines.

Niobium:

This is the first time that this element has been reported (in literature) present in this star. There were fifty-three NbI and five NbII lines and eight lines with no ionization states assigned.

Molybdenum:

This too is the first time that this element has been reported (in literature) present in this star. There were seventy MoI lines identified and fifteen lines where no ionization states were assigned.

Technetium:

Since Molybdenum has been identified there is no reason to doubt that its parent would also be present. There were forty-eight TcI lines tentatively identified.

Ruthenium:

This is another element which has not been reported present prior to this time in this star. There were forty-three lines of RuI measured and six lines of ruthenium without an ionization state designation.

Rhodium:

This is still another new element reported. There were thirteen RhI lines and two rhodium lines without ionization state designations.

Palladium:

This too is another element reported present for the first time. There were eight PdI lines measured and recorded.

Cadmium:

This element has also not been reported present in this star before this time. There were four CdI lines and one CdII line reported.

Indium:

This is another that has not been reported present in this star. However, the longest lived isotope, In^{115} , has a half-life of 6×10^{14} years which would make this identification a probable one. There were six InII lines recorded.

Xenon:

This element has not appeared in literature for this star, however, it has been identified by Bidelman (1972). There were nine lines of XeI and five lines of XeII measured and recorded.

Caesium:

The presence of this element is somewhat questionable since only six lines of CsI were measured and recorded.

Barium:

There were eighteen BaI lines and ten BaII lines measured and recorded.

Lanthanum:

This is the first element in the lanthanide series of the rare earths. There were forty-three LaI lines and seventy-three LaII lines measured. The most interesting thing to note is the presence of the five strongest lines of LaIII.

Cerium:

This is another one of the overabundant elements present in this star. Ninety-one new lines of CeI and two-hundred and ninety-one new lines of CeII as well as one-hundred and forty-two new lines of cerium without any ionization state assigned are listed. In addition to these lines, thirty lines of CeIII which are in agreement with Adelman, Shore, and Tiernan's (1973) identification were located.

Praseodymium:

This is another overabundant element. There were twenty-one new lines of PrI and sixty-four new lines of PrII and forty-three lines without an ionization state designation. In addition, there were fifty-six lines of PrIII measured which are definitely present or attributed to blends. These too were in agreement with Adelman, Shore, and Tiernan's (1973) identification.

Neodymium:

This is another overabundant element. There were fifty-seven new lines of NdI and one-hundred and twenty new lines of NdII as well as twenty-eight lines without an ionization state designation. In addition to these lines there were nine NdIII lines found which also agree with Adelman's (1974) identification.

Promethium:

There were eighty-six PmII lines identified. This is the first time that promethium has been reported in this star. However many of these lines are questionable since they are attributed to blends. On the other hand many lines had wavelengths that corresponded to unidentified features which were very close to the laboratory wavelengths of PmII.

Samarium:

There were fifty-nine new SmI lines and one-hundred and eighty new SmII lines measured as well as forty-seven lines without an ionization state designation. In addition to these there were sixteen lines of SmIII reported which also agree with Adelman's (1974) identification.

Europium:

There were forty-eight new lines of EuI and thirty-nine new lines of EuII measured as well as forty-seven lines without an ionization state designation. There were no EuIII lines measured.

Gadolinium:

There were seventy-two new lines of GdI and one-hundred and eighty-three new lines of GdII measured. Twenty-five lines without

an ionization state designation were also measured.

Terbium:

After a search of the accessible data there has been nothing reported about terbium being present in Beta Coronae Borealis. Lines for TbI and TbII have been measured with some certainty. Hiltner (1945) only reported one line of TbII at 4005.57Å. There were thirty-five new lines of TbI and forty-three new lines of TbII measured. Eleven lines measured were attributed to terbium without an ionization state designation. In addition to these lines there were twenty-five lines of TbIII measured. This is the first time that TbIII has been reported in Beta Coronae Borealis.

Dysprosium:

There were fifty-seven new lines of DyI and ninety-six new lines of DyII measured and twenty-three lines without an ionization state designation. A search for DyIII proved unsuccessful.

Holmium:

This too is another element that has not been reported present in Beta Coronae Borealis until the paper of Adelman, Shore, and Tiernan (1973). There were forty-two new lines of HoI and thirty new lines of HoII measured and twelve lines without an ionization state designation. Other HoII lines were in good agreement with those of Adelman, Shore, and Tiernan's (1973) identification. Insufficient data suppressed the search for HoIII lines.

Erbium:

This is the first time, to the author's knowledge, that this element has been reported present in Beta Coronae Borealis. There were forty new lines of ErI and forty-two new lines of ErII measured and thirteen lines without an ionization state designation. Most of the stronger lines of ErI were in fact measured but all are not included here. In addition, the six strongest lines of ErIII were measured with some certainty.

Thulium:

This is another element which has not been reported present in Beta Coronae Borealis. The only exception is Hiltner's (1945) identification of one line of TmII at 4199.92Å. There were twenty-two new lines of TmI and sixteen new lines of TmII measured. Eight lines were attributed to thulium without an ionization state designation.

Ytterbium:

There were eleven new lines of YbI measured for Beta Coronae Borealis and eleven new lines of YbII. These were in good agreement

with what Adelman, Shore, and Tiernan (1973) had identified. In addition, there were ten lines without an ionization state designation attributed to ytterbium. There were also nine lines of YbIII measured and reported for the first time in this star.

Lutecium:

This element has not been reported present in this star. However, nine lines were measured and their wavelengths closely corresponded to those of LuI. Eleven other lines had wavelengths nearly the same as those of LuII. Four additional lines that were measured were moderately strong and did not have an ionization state designation.

Hafnium:

This element also has not been reported present in this star, however, forty-three new lines of HfI and seventy-three new lines of HfII have been measured and recorded.

Tantalum:

This is another new element to be identified for the first time in this star. There were fifty-seven new lines of TaI measured and only four lines without an ionization state designation.

Tungsten:

This element's presence is quite unusual in A-stars, however, there were forty-three new lines of W I measured, some of which were in agreement with Brandi and Jaschek (1970); while eight lines were attributed to tungsten that had no ionization state designation.

Rhenium:

This is another new element. There were seventeen lines of ReI measured and two lines without any ionization state designations.

Osmium:

This too is a new element present. The lines that Brandi and Jaschek (1970) tentatively identified have also been found on the tracings. There were thirty-seven lines of OsI and four lines without an ionization state designation measured.

Iridium:

This element has never been reported in Beta Coronae Borealis prior to this time. There were only six lines of IrI measured and they were moderately strong. The presence of this element is quite questionable.

Platinum:

This is another unusual element present in this star. There were only eight lines of PtI measured and recorded (all of these were moderately strong). There is some doubt about these identifications.

Gold:

This is quite unusual to find in A-stars, however, only five lines of AuI were identified and were very weak on the tracings. The lines do have relatively strong laboratory intensities. It is somewhat doubtful that this element is present in this star.

Mercury:

Indications point to the fact that this element is probably present. It would require a more detailed search in order to have a decisive opinion. There were only five HgI lines measured and recorded. These lines were fairly weak on the tracings but with strong laboratory intensities.

Lead:

It is quite doubtful that lead is present in Beta Coronae Borealis. The three lines measured had wavelengths closely corresponding to those of PbI. Their laboratory intensities were moderately strong, however, the features on the tracings were quite weak.

Bismuth:

Only one line was measured whose wavelength corresponded to BiI at 4121.55Å. The line was very weak and it is a possible blend with a SmII line at 4121.54Å.

Actinium:

There were ten lines of AcI identified and fifteen lines of AcII. It is very unlikely that this element is present since the longest lived isotope of Actinium, Ac²²⁷, has a half-life of 21.6 years.

Thorium:

There were sixty-six lines of ThI and fifty lines of ThII identified. Some features appeared by themselves on the tracings while others due to blends contribute support to their identification. Five lines attributed to thorium did not have an ionization state designation.

Protactinium:

There were six PaII lines identified, however, these identifications are somewhat doubtful. The longest lived isotope, Pa²³¹, has a half-life of 3.43×10^4 years which makes this identification of protactinium somewhat questionable.

Uranium:

There were twenty-nine lines of UI (including the stronger laboratory intensities) identified. There were also twenty-nine lines of UII identified most of which agreed with Adelman and Shore's (1973) identification and with Brandt and Jaschek (1970). There were also thirteen lines without an ionization state designation which may be attributed to uranium.

Neptunium:

There were twenty-nine lines tentatively identified for NpI. However, the data obtainable at this time are not as accurate as one needs to make a positive identification. The longest lived isotope of neptunium, Np²³⁷, has a half-life of 2.20×10^6 years which makes it possible for this heavy element to be present. However, the results here are inconclusive.

Plutonium:

A search for PuII lines by Adelman and Shore (1973) yielded a null result. However, several lines were measured here whose wavelengths corresponded to those of plutonium. There were fifty-four lines measured in all. Some of these lines were due to blends while others were associated with unidentified features on the tracings. The longest lived isotope of plutonium, Pu²⁴⁴, has a half-life of 8.0×10^7 years which makes its presence possible. The source used in the identification was the Joint Establishment for Nuclear Energy Research, Report Number 51.

Americum:

There were twenty lines measured which may be due to the presence of AmI and twenty-five lines due to the possible presence of AmII. Since the half-life of the longest lived isotope, Am²⁴³, is 7.95×10^3 years, it seems unlikely that this superheavy element is present.

Curium:

There were forty-one lines measured which may be due to the presence of CmII. Some of the wavelengths measured were due to blends while others were associated with unidentified features. The longest lived isotope of curium, Cm²⁴⁷, is $\geq 4.0 \times 10^7$ years which makes this element's presence quite possible.

Berkelium:

There were nine lines whose wavelengths corresponded to those of BkII. Two unidentified features on the tracings corresponded to the two strongest lines of BkII. However, the longest lived isotope of berkelium, Bk²⁴⁷, has a half-life of approximately 104 years. This indeed would make these identifications quite out of the question.

Californium:

A search for CfII was unsuccessful. The longest lived isotope of Californium is about 800 years which makes its presence quite doubtful.

Einsteinium:

A search for EsII was made with some apprehension since the half-life of the longest lived isotope of einsteinium, Eu²⁵⁴, is about 480 days. There were five lines corresponding to the strongest laboratory intensities of einsteinium but they were due to blends. It is very doubtful that this element is present.

UNIDENTIFIED LINES:

There are still approximately 700 lines that remain unidentified in the spectrum of Beta Coronae Borealis on the intensity tracings for the wavelength region $\lambda\lambda 3400-6959$.

The work in this thesis was based on the measurements of wavelengths as well as those of line coincidences with the density tracings of γ Equulei. No intensities were assigned to the lines identified but yet the number of lines present is some indication of strength. In closing this is a necessary and significant step toward our final goal and that is to make an abundance determination for Beta Coronae Borealis of all the elements present in this star.

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