

LINE IDENTIFICATIONS FOR THE
STAR BETA CORONAE BOREALIS

By

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CHAPTER I

INTRODUCTION

The importance of stellar abundance determinations has been stated by A. Unsöld (1969): "Spectroscopic determination of the abundances of the chemical elements in stellar atmospheres provides us with most important indications on stellar evolution. In the vast majority of 'normal' stars the chemical composition of the outer layers is, it turns out, unaffected by the energy-producing nuclear processes in the stellar interior. The composition of the atmosphere of such stars therefore gives us information on the composition of the interstellar matter out of which they originated.

"There are, however, rare kinds of stars with atmospheres of highly anomalous composition--the helium-, barium-, carbon-, and 'peculiar' stars, usually designated according to the element whose spectral lines appear strengthened. In such cases we can investigate which nuclear processes were active in transforming the matter that we now observe directly, and we are faced with the problem of explaining how the star managed to 'turn inside out'."

Or in a few words, "abundance analysis of stellar spectra reveals nuclear evolution in stars and galaxies."

The first step in making stellar abundance determinations is preparing an identification list of the elements present in the stellar atmosphere. This identification list can be prepared from analysis of

the spectrogram of the star.

The purpose of this work is to provide such an identification list for the peculiar star Beta Coronae Borealis. This star is peculiar because it has more europium, chromium, and strontium lines than "normal" stars.

Intensity tracings were made by Dr. Leon W. Schroeder during June 1971 and January 1972 from a spectrogram of β Coronae Borealis. From these intensity tracings an identification list has been prepared covering the wave-length interval $\lambda\lambda 3613-4863$. Beta Coronae Borealis (1900: $\alpha = 15^{\text{h}} 23^{\text{m}} 7^{\text{s}}$, $\delta = +29^{\circ} 27'$, photographic apparent magnitude 3.72) is an A5 p (peculiar) spectral type star.

Beta Coronae Borealis has previously been studied by means of lower-dispersion spectra in the region $\lambda\lambda 3980-4638$ by W. A. Hiltner (1945). The present reexamination of this spectrum is justified on the basis of our better, higher-dispersion spectrogram and the broader interval over which the spectrum was analyzed. While the line measurements in this paper were measured from intensity tracings of the spectrum, Hiltner (1945) used a short-screw measuring engine directly on the spectrogram.

Detailed abundance analysis will be carried out later by others in which the line identifications made here will be used. One approach to this detailed abundance analysis, labeled "grobanalysis" by German workers, utilizes a curve of growth technique which makes use of a readily-obtainable datum, the equivalent width of a line. This type of preliminary investigation serves as a basis for more detailed "fine" analyses of line profile studies based on model stellar atmospheres.

CHAPTER II

OBSERVATIONAL MATERIAL

The Spectrogram

The spectrogram from the A5p star β Coronae Borealis used in this study was taken by Dr. Leon W. Schroeder, Dr. Ronald K. Oines (both from Oklahoma State University) and by Dr. John C. Evans (Kansas State University) at the coudé focus of the 84-inch telescope at the Kitt Peak National Observatory on June 13, 1971. This observatory is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation. Table I below contains data on the spectrogram and on the spectrograph and camera used to record it.

The spectrogram itself is about 1500\AA wide and was exposed on 28 inches of photographic plate (2-10 inch strips and 1-8 inch strip). The 28 inch plate (D-2829a) contains the absorption spectrum from about 3600\AA to about 5000\AA . The image of the spectrum from about 4900\AA - 5000\AA was too faint to measure.

A representative sample of the spectrogram used is shown in Figure 1 below.

A second spectrogram numbered D-2836a was also taken during the same observing session but the identification list here does not include any measurements from D-2836a. The decision not to use D-2836a was based on reasons given later.

TABLE I
DATA FOR 84-INCH COUDÉ SPECTROGRAPH

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: 8000Å (1st order)
Ghost intensity: 0.06% of parent line

CAMERA: 6

Grating tilt: 7935	f-ratio: f/16
Plate position: 46.0	Focal length: 143.8 inches
Central wavelength: 4400Å	Demagnification from slit to plate: 1.88
Focus: 60.60	Dispersion (2nd order blue): 2.2 Å/mm
Tilt: 4.15	Plate width: 27/32 inches
Emulsion II a-0	Plate length: 28 inches
Exposure meter count: 15988	Starlight exposure time: 39 minutes
Calibration: Sensitometer, 5-74 filter; Neutral density factor x 100; Exposure time 21 minutes.	Iron arc comparison exposure time: 10 sec (no filter)
Developer: D-19 for 4 minutes	Temperature in spectrograph room: 61°F

POSITION OF STAR:

Hour angle: 15^h 23^m.9
Declination: +29^o 27'

OBSERVING CONDITIONS:

Seeing: 1
Trans: 4
Photographic apparent magnitude: 3.93

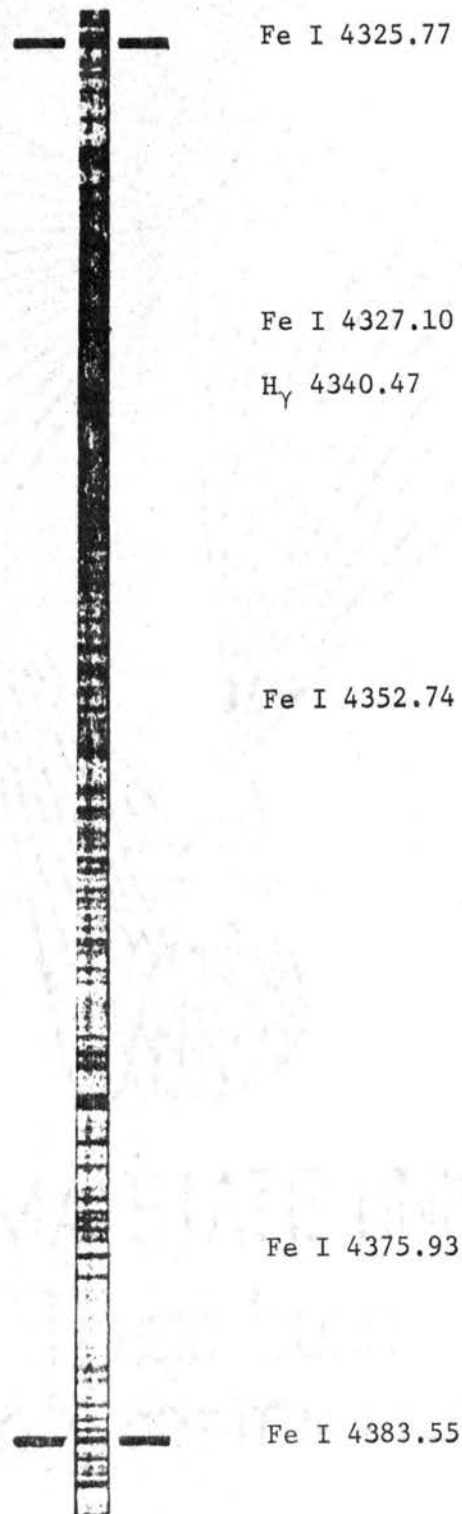


Figure 1. Sample of Spectrogram With Iron Arc Comparison Lines and H γ Identified

Intensity Tracings

Intensity tracings were made by Dr. Leon W. Schroeder during June 1971 and January 1972 with the Hilger-Watts Direct Intensity Recording Microphotometer, Model L-470 at Kitt Peak National Observatory headquarters in Tucson, Arizona. Of the three tracings made from the three sections of the photographic plate D-2829a, the central wavelength tracing was made in June 1971 and the carriage speed for that tracing was 0.5 millimeter/minute while the plate-to-chart mag. was 102.5/1. The short and long wavelength tracings were made in January 1972 and the carriage speed for these two tracings was 1.0 millimeter/minute while the plate-to-chart magnification was 51.3/1. Table II below gives pertinent data for the settings on the microphotometer when the tracings were made.

TABLE II
DATA FOR MICROPHOTOMETER

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

In a letter dated 9 February 1972 from Ingemar Furenlid, Kitt Peak National Observatory, he said "I very much regret to inform you that a faulty beam splitter in the microphotometer has affected the quality of your tracings. Spectra of high density will show stronger distortions than spectra of low density. If the field illumination was left on dur-

ing the recording of spectra, distortion will be worse.

"Quantitative information should preferably not be derived from the spectra."

Fortunately, the above will not adversely affect line identifications made from these tracings. The distortions would adversely affect any measurements made using vertical measurements on the tracings but the distortions should not affect horizontal measurements.

As a consequence, no line profile, equivalent width, or intensity measurements should be made from any of the tracings of plates D-2829a or D-2836a except the one tracing from the middle section of the plate D-2829a made in June 1971. All of the tracings except for the one mentioned above will have to be reproduced for subsequent work. But the line identifications will not need to be made from the new tracings since those that have been done will be valid. It will then be possible to transpose the identifications from these tracings directly to the new tracings.

Tracings from D-2836a were not used because of the difficulty encountered in making positive identifications of the strong absorption lines on it. Even though the two spectrograms D-2829a and D-2836a overlap one another spectrally, it was difficult to identify H_{β} ($\lambda 4861.33$) on D-2836a. The reason for this difficulty was probably due, as mentioned earlier, to the faulty beam-splitter in the microphotometer used to record the tracing at Kitt Peak which caused distortion of the profile. Consequently, this tracing was not employed in this study.

A portion of one of the direct intensity microphotometer tracings is contained on page 8 in Figure 2. This particular portion was chosen because the strongest line in the spectrum of Eu-I was identified here.

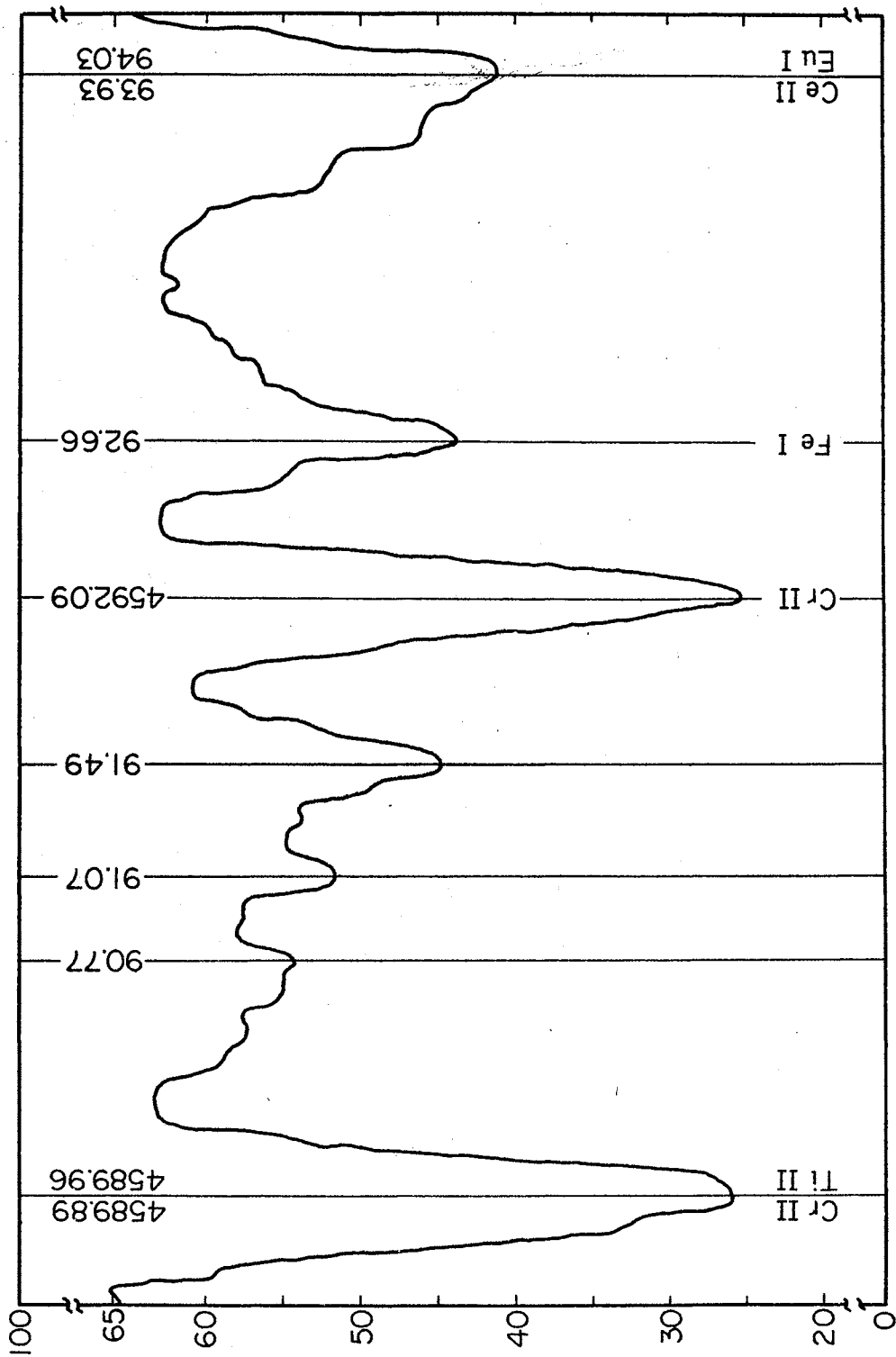


Figure 2. Scale Drawing of Microphotometer Tracing With Lines Identified

CHAPTER III

IDENTIFICATION OF SPECTRAL LINES

Method of Line Identification

Identifications were made on a new tracing initially by locating the strong hydrogen lines along with their broad profiles. In the spectral region of concern in this work the hydrogen lines were frequent enough to make good identification possible. After all of the hydrogen lines were identified the other strong lines were identified. In order to make the identifications it was assumed that there is a nearly linear relationship between distance along the abscissa of the tracing and the wavelength, as would be expected from grating spectra. The dispersion curves displayed later verify this assumption.

Utilizing this assumption for two strong lines that are properly identified it is possible to determine this relationship (dispersion). Then using the dispersion (angstroms/inch) it is easy to measure the wavelength for all of the lines between the two strong ones. In this fashion wavelength measurements can be made from the first absorption line recorded on the tracing to the last one. It is important, however, to realize that the strong lines must be properly identified otherwise all subsequent identifications will be wrong. Dispersion curves over spectral range considered are shown below in Figures 3, 4, and 5.

The strong absorption lines were confirmed with the help of the identification list prepared by W. P. Bidelman and secured from Dr. Evans

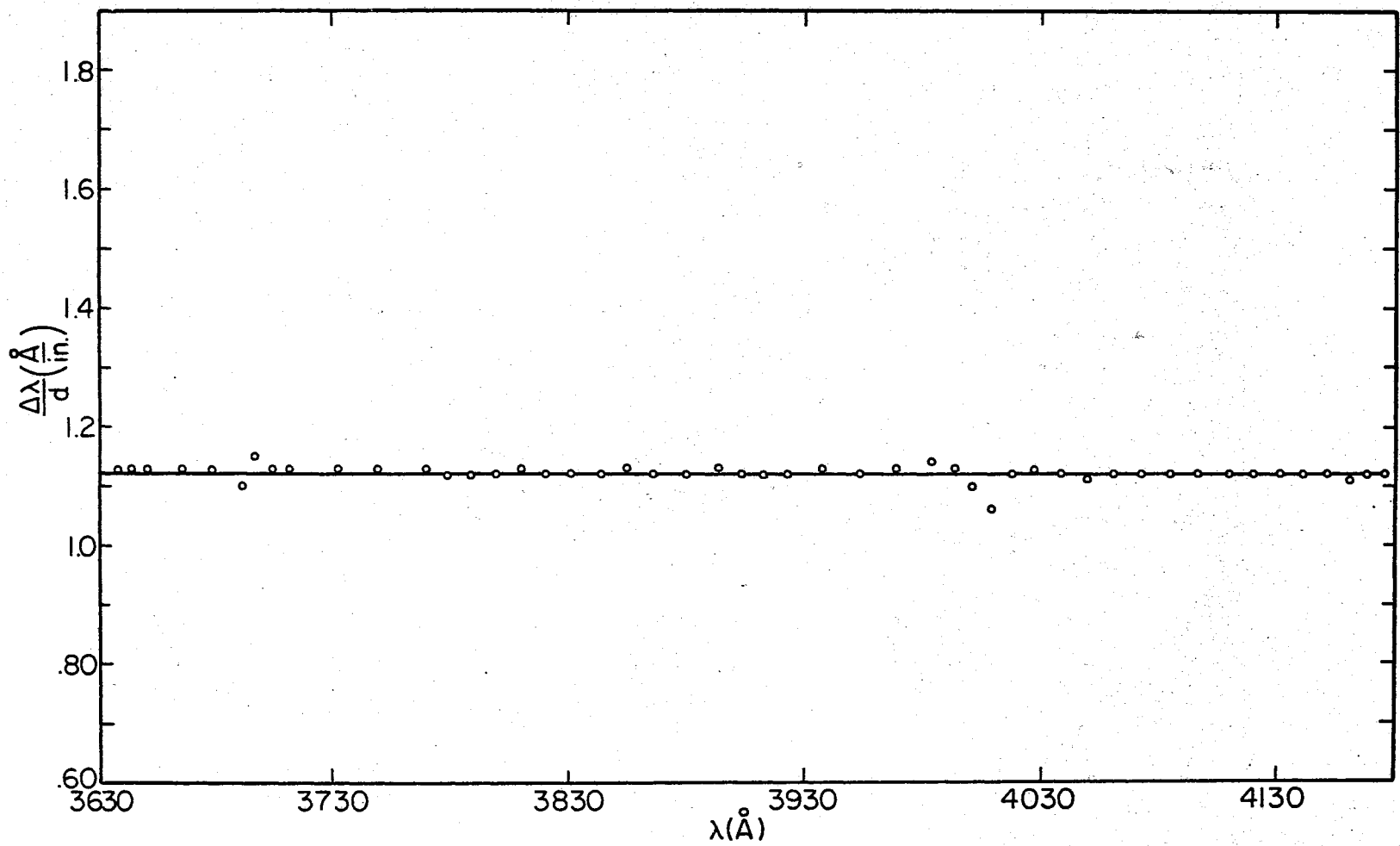


Figure 3. Dispersion for Short Wavelength Tracing Recorded at 1.0 Millimeter/Minute

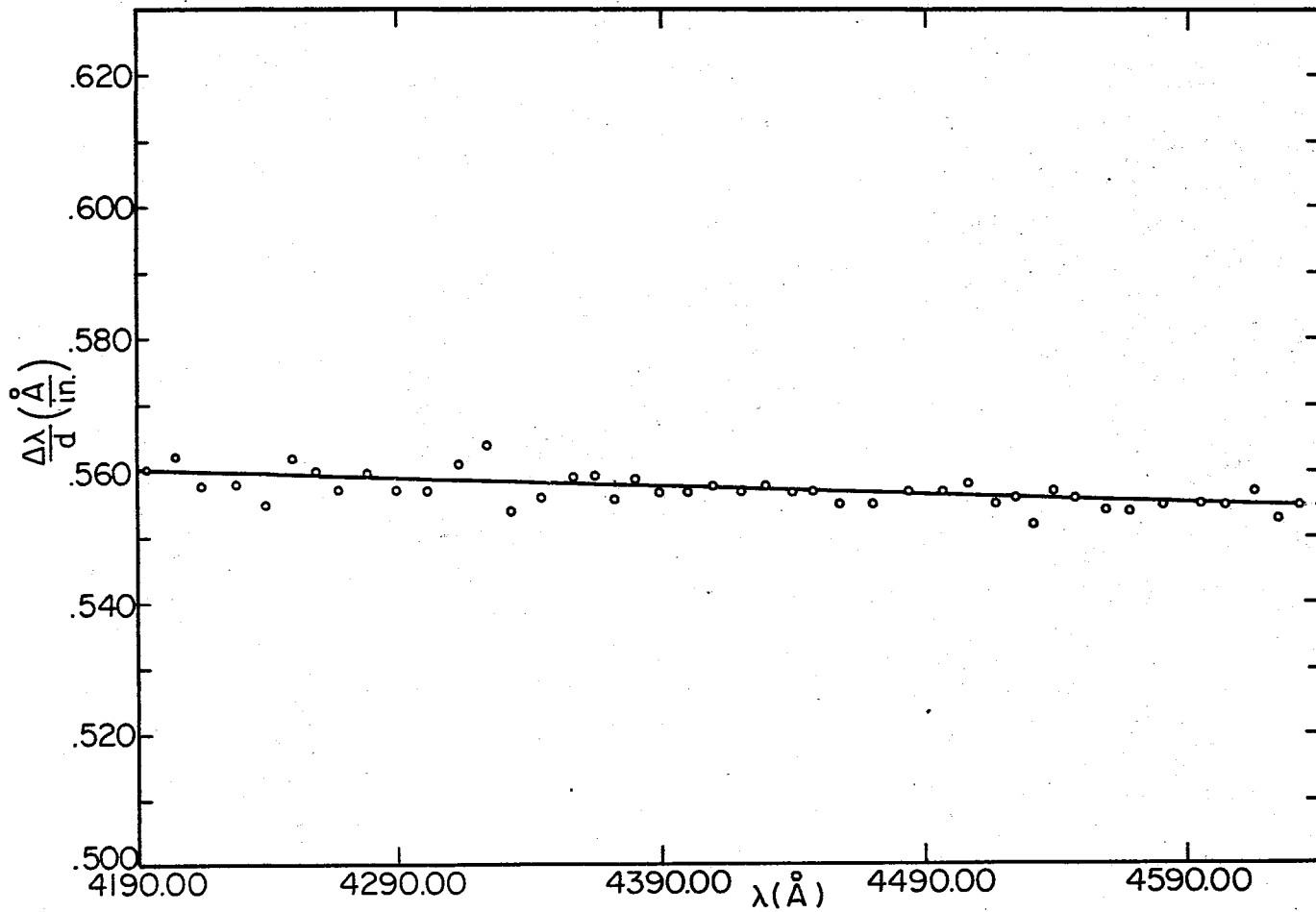


Figure 4. Dispersion for Central Wavelength Tracing Recorded at 0.5 Millimeter/Minute

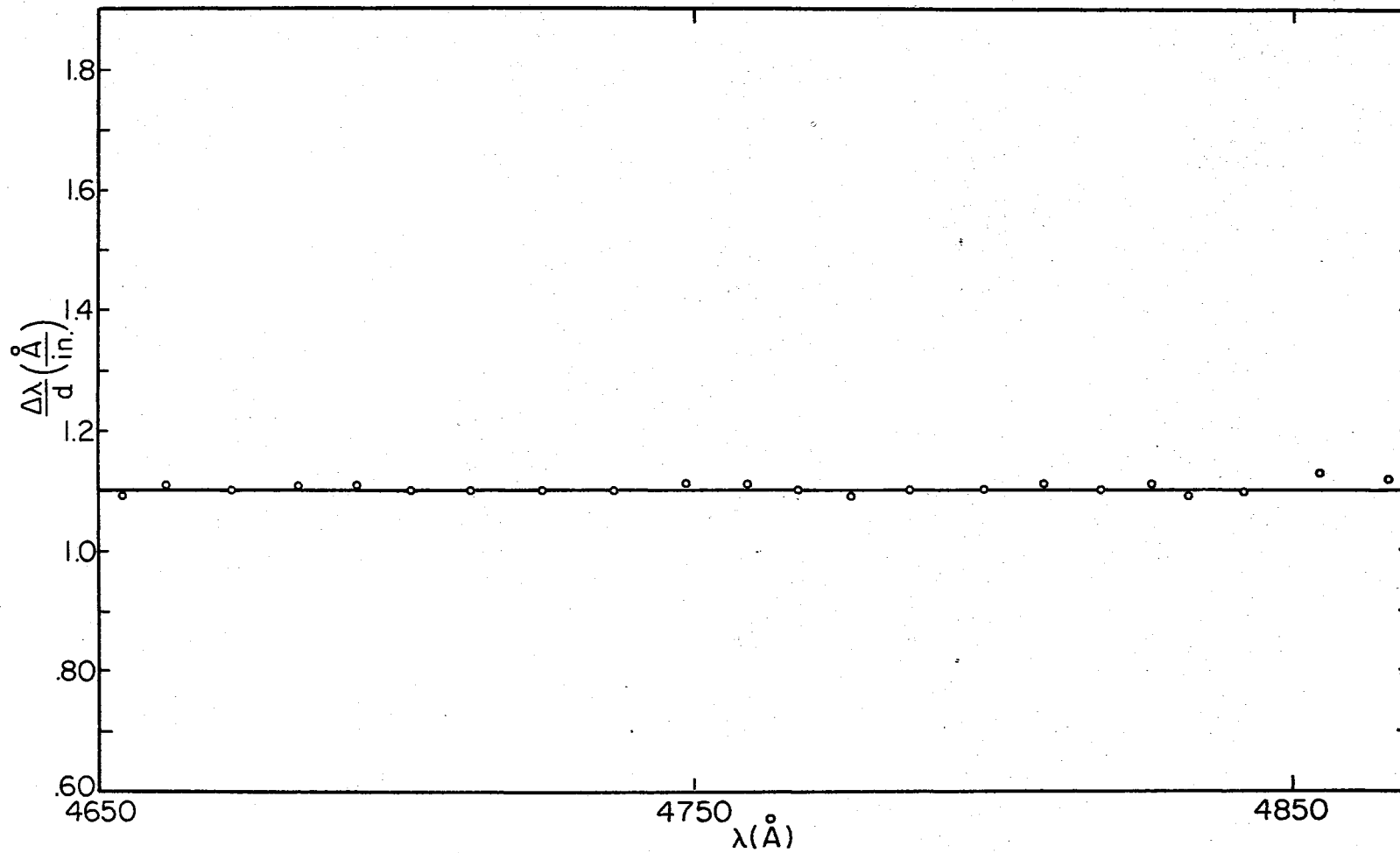


Figure 5. Dispersion for Long Wavelength Tracing Recorded at 1.0 Millimeter/Minute

at Kansas State University. This listing was prepared from γ Equulei which is the same type star as Beta Coronae Borealis.

In the spectral range $\lambda\lambda 3987-4642$ the line identifications made by W. A. Hiltner (1945) provided a valuable source from which comparison was possible since the star studied by Hiltner was the same as the one considered in this work.

The source of identification was A Multiplet Table of Astrophysical Interest (revised edition) by Charlotte E. Moore (1959). This book contains highly useful information in a "Table of Multiplets" and a "Finding List" of all lines in the "Table of Multiplets." From the "Finding List" in the back of the book it was possible to select the wavelength (RMT) corresponding to the wavelength measured.

Explanation of Identification Tables

In Hiltner's table of line identifications the measured wavelength is recorded, corrected for radial velocity and curvature of spectral lines. "The correction for radial velocity and curvature", according to Hiltner, "increased uniformly from $0.074\overset{\circ}{\text{\AA}}$ at $\lambda 4000$ to $0.087\overset{\circ}{\text{\AA}}$ at $\lambda 4480$, but it then decreased rapidly to $0.05\overset{\circ}{\text{\AA}}$ at $\lambda 4600$."

In the work done for this thesis all the lines from the tracings show the effects of the radial velocity of β Coronae Borealis. By choosing two strong lines and using their laboratory wavelengths ($\lambda(\text{RMT})$) the dispersion for the range between them cancels the effect of the radial velocity in that range.

The absorption lines identified in the spectrum of β Coronae Borealis are listed in Tables III, IV and V. The wavelengths measured were generally different than those in Moore's Revised Multiplet Table (RMT).

but the λ (RMT) are the ones that are reported here.

The first column gives the λ (RMT) in international angstrom units. The second column identifies the element, its state of ionization and the multiplet numbers as given in Moore (1959). If the symbol for the element is preceded by P this means that this was a calculated value and is a probable identification. The third column gives an indication of whether Hiltner or Bidelman observed this absorption line in their efforts. The following key gives an explanation of the symbols used in this column:

H 1	Hiltner reports line the same
H 2	Hiltner reports line present but no identification
H 3	Hiltner reports line differently
Blank	Hiltner does not report line
B 1	Bidelman reports line the same
B 2	Bidelman reports line present but no identification
B 3	Bidelman reports line differently
Blank	Bidelman does not report line

Each table corresponds to measures from a tracing made from one of the three sections of plate D-2829a.

Two small spectral regions are missing at the end of the first section and at the end of the second section of D-2829a. These portions are missing because the spectrogram was recorded on these three sections with two small breaks between them.

Line Identification Tables III, IV and V follow:

TABLE III
 LINE IDENTIFICATIONS FOR $\lambda\lambda 3613-4181$

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
3613.39	Gd II-69	B2	3644.41	Ca I -9	B1
3613.70	Ce II-110		3644.70	Ti I-uncl.	B3
3614.79	Zr II-9	B1	3645.31	Sc II-2	B1
3615.66	Fe I -46		3646.19	Gd II-2	B1
3616.15	P Fe I -569	B1	3646.65		B3
3617.32	Fe I-uncl.	B1	3646.97	Ce II-66	
3617.32	Cr II-147	B1	3647.40	Cr II-1	B1
3617.79	Fe I -496	B1	3647.84	Fe I -23	B1
3618.77	Fe I -23	B1	3648.35	Hf II-39	
3619.46	Cr I -48	B3	3648.53	Cr I -47	
3620.23	Fe I -324		3649.00	Cr I -47	B1
3621.20	V II-76	B1	3649.51	Fe I -291	B1
3621.22	Co II-1	B1	3650.28	Fe I -180	B1
3622.54	Eu II-18	B3	3650.37	Cr II-156	B1
3623.79	Mn I -8	B1	3651.03	P Fe I -571	
3624.83	Ti II-51	B1	3651.10	Fe I -322,674	
3625.14	Fe I -323	B1	3651.80	Sc II-2	
3626.32	Gd II-69		3652.54	Co I -4	B1
3627.05	Fe I -808		3653.11	Ce II-38	
3628.09	Fe I -77		3653.62	P Sc II-18	
3628.71	Y II-9	B1	3653.67	Ce II-50	
3629.10	P Sc II-18		3653.76	Fe I -180	
3629.12	Zr II-113		3654.62	Gd II-4	B1
3629.51	Gd II-69		3654.98		B2
3630.26	P Ni I -180		3655.85	Ce II-51	
3630.75	Ca I -9	B1	3656.23	Fe I-uncl.	B1
3631.46	Fe I -23	B1	3657.14	Fe I -130	
3631.49	Cr II-12	B1	3658.19	Cr II-98,146	B1
3632.04	Fe I -496	B1	3659.23	Ce II-54	
3632.29	Fe II-112	B1	3659.77	Ti II-75	B1
3633.13	Y II-2	B1	3660.64	Ce II-42	
3634.29	Sm II-19	B1	3661.37	Sm II-6	B1
3634.33	Fe I -389	B1	3661.38	V II-191	B1
3634.70	Fe I-uncl.	B1	3661.73	Hf II-62	
3635.19	Fe I -490	B1	3662.24	Ti II-75	B1
3636.59	Cr I -47	B1	3662.84	Cr I -46	B1
3637.73	Fe I -229		3663.64	Zr I -12	
3638.16	P Fe I -324		3664.62	Y II-9	B1
3638.30	Fe I -294	B1	3664.95	Cr II-156	B1
3638.99		B2	3665.48	P Cr II-1	
3639.76	P Sc II-18		3666.02	P Cr II-145	
3640.39	Fe I -295	B1	3666.24	Fe I -179,389	
3641.33	Ti II-52	B1	3667.25	Fe I -570	B1
3642.79	Sc II-2	B1	3668.00	Fe I -438,569	B3
3643.18	Co I -99	B3	3668.21	Fe I -568	
3643.63	Fe I -385	B1	3668.72	Ce II-38	

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
3669.15	Fe I -437	B1	3696.78	Cr II-131	
3669.52	Fe I -291	B1	3697.62		
3670.04	Fe I -369	B1	3698.61	Fe I -491	B1
3670.07	Fe I -435	B1	3699.15	Fe I -490	
3670.59			3699.73	Gd II-20	B1
3671.20	Gd II-2	B1	3700.26	Tm II-6	B3
3671.94	Cr I -217		3701.09	Fe I -385	B1
3672.17	Ce II-49		3701.90	Cr II-168	
3672.69	Fe I -180	B3	3702.50	Fe I -46,75	B2
3673.16		B2	3702.82		B3
3673.68	P Fe I -978		3703.56	Fe I -291	B1
3674.06	P Ni I -15	B3	3703.58	V I -29	B1
3674.43		B3	3703.86	H -16	
3674.74	Zr II-9	B1	3703.82	Fe I -369	B1
3675.31	Ca I -28		3704.46	Fe I -290	B1
3676.31	Fe I -228	B1	3705.04	V I -29	
3676.33	Cr I -89	B1	3705.57	Fe I -5	B1
3676.55	Co I -145	B1	3706.03	Ca II-3	B1
3677.31	Fe I -773	B1	3706.22	Ti II-73	B1
3677.86	Cr II-12	B1	3706.59		
3677.93	Cr II-12	B1	3707.05	Fe I -385	B1
3678.34	Sc II-45		3707.83	Fe I -5	B1
3678.91	Zr II-101	B1	3707.92	Fe I -76	B1
3679.14	P Ti I -177		3708.45	Fe I -436	
3679.67	Ti II-75	B1	3709.25	Fe I -21	B1
3679.92	Fe I -5	B1	3709.67	Fe I -225	
3680.80	Fe I-uncl.		3710.01	P Cr II-6	
3681.69	Cr I -89	B1	3710.30	Y II-7	B1
3682.17	P Fe I -385		3710.73		
3682.67	Zr II-44	B2	3711.97	H -15	
3683.05	Fe I -5	B1	3712.97	Cr II-12	B1
3684.22		B2	3713.56	V I -98	
3685.19	Ti II-14	B1	3714.77	Zr II-18	B1
3685.47	P Ti I -177		3715.19	Cr II-20	B1
3686.00	Fe I -385	B1	3715.48	V II-15	B1
3686.26	Fe I -131	B1	3715.91	Fe I -124	B1
3686.67	Cr II-118	B1	3716.44	Fe I -388	B1
3687.74	Gd II-20	B1	3717.02	Zr II-82	B2
3688.42	Eu II-2	B1	3717.55	V I -114	
3689.46	Fe I -369	B1	3718.41	Fe I -292	B1
3689.90	Fe I -533		3718.86	Zr II-9	B1
3690.70	V II-190	B3	3718.88	Sm II-38	B3
3691.07			3719.45	Gd II-uncl.	B1
3692.39			3719.94	Fe I -5	B1
3692.81	Mn I -7		3720.55		
3693.36	Co I -64		3721.63	Ti II-13	B1
3694.01	Fe I -394	B1	3722.03	Fe I -291	
3694.75		B3	3722.56	Fe I -5	B1
3695.86	Cr I -217	B3	3723.32	V I -98	

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
3723.63	Ti II-72	B1	3748.01	Ti II-107	B1
3724.26	P Ni I -183		3748.68	Cr II-11	
3724.90	Sm II-5		3748.88	Gd II-105	
3724.94	Eu II-2	B1	3750.15	H -12	
3725.50	Fe I -534	B1	3752.42	Fe I -385,392	B1
3726.29			3753.61	Fe I -73	B1
3726.93	Fe I -385	B1	3754.59	Cr II-20	B1
3727.35	V II-21	B1	3755.19		B3
3727.37	Cr II-117	B1	3755.70	V I -124	
3727.62	Fe I -21	B1	3756.12		B2
3728.34	V II-116	B1	3756.55	Cr II-144	
3728.67	Fe I -227		3756.96	Zr II-8	B2
3728.93	Ni I -181	B2	3757.17	Cr I -43	
3729.74	Zr II-8	B1	3757.68	Ti II-72	B1
3729.81	Ti I -17	B1	3758.24	Fe I -21	B1
3730.39	Fe I -533	B1	3759.29	Ti II-13	B1
3730.84	Gd II-20	B1	3760.05	Fe I -177	B1
3731.26	Zr II-112	B1	3760.53	Fe I -76	B1
3731.93	Mn I-unc1.		3760.69	Sm II-18	B1
3732.39	Co I -62	B1	3761.32	Ti II-13	B1
3732.40	Fe I -76	B1	3761.87	Ti II-107	B1
3734.37	H -13		3762.21	Fe I -705	B1
3735.93	Co I -95	B1	3762.89	Fe II-192	B1
3735.98	Sm II-29	B1	3763.33	Gd II-37	
3736.90	Ca II-3	B1	3763.79	Fe I -21	B1
3737.13	Fe I -5	B1	3764.09	Fe II-29	B2
3737.55	Cr II-117	B1	3764.12	Ce II-41	B2
3738.38	Cr II-20	B1	3764.60	Gd II-85	
3739.12	Sm II-unc1.	B1	3765.04	Ce II-208	
3739.12	Fe I -75	B3	3765.54	Fe I -608	B1
3739.53	Fe I -unc1.	B1	3765.62	Cr II-20	B1
3740.06	Fe I -532a,	B1	3765.93	Eu II-11	
	707		3766.65	Cr II-20	B1
3740.25	Fe I -667	B1	3767.19	Fe I -21	B1
3741.63	Ti II-72	B1	3768.39	Gd II-2	B1
3742.20	P Cr II-6		3769.46	Ni II-4	B1
3742.62	Fe I -387	B1	3770.63	H -11	
3743.47	Gd II-2	B1	3773.19		
3743.99			3774.33	Y II-7	B1
3744.56	Ni I -180		3774.65	Ti II-12	B1
3745.11			3775.57	Ni I -33	B1
3745.56	Fe I -5	B1	3776.06	Ti II-72	B1
3745.81	V II-15	B1	3776.56	Y II-8	B1
3745.90	Fe I -5	B1	3777.06	Fe I -432	B1
3746.49	Fe I -73		3777.54	Co I -96	B1
3746.93	Fe I -386	B1	3778.36	V II-21	B1
3747.19			3778.70	Fe I -73	B1
3747.55	Y II-8	B1	3779.05		

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
3779.58	P Fe II-23	B2	3706.20	Fe I -731	B2
3779.84			3706.70	Fe I -607	B1
3780.09	Hf II-18		3706.72	Mn I -6	B1
3780.67	La II-55	B2	3707.14	Ni I -33	B1
3781.19	Fe I -74	B1	3707.53	Fe I -73	B1
3781.60	Mo I -8		3708.12	Ce II-59	B1
3781.94	Fe I -917	B1	3708.73	Fe I -222	B1
3782.34	Gd II-uncl.	B1	3709.22	Ce II-204	
3783.35	Fe II-14	B1	3709.59	Mn I -6	B1
3784.25	Nd II-uncl.	B1	3710.21	P Fe II-143	
3785.42	Mn I -45	B3	3810.76	Fe I -665	B2
3786.22	Cr I -71	B3	3811.58		
3786.68	Fe I -22	B1	3811.89	Fe I -287	B2
3787.20	Sm II-5	B3	3812.25	Cr I -214	B1
3787.56	Gd II-20	B1	3813.06	Fe I -222	B1
3787.88	Fe I -21	B1	3813.39	Ti II-12	B2
3788.39		B3	3813.64	Fe I -283	B1
3788.75	Ce II-47		3813.97	Gd II-2	B1
3789.18	Fe I -289	B1	3814.58	Ti II-12	B1
3789.41		B2	3815.50	Eu II-uncl.	
3789.82	Fe I -702	B1	3815.84	Fe I -45	B1
3790.10	Fe I -22	B1	3816.34	Fe I -73	B1
3790.45	Cr I -139	B1	3816.75	Mn I -6	B1
3791.17	Gd II-85	B1	3817.72		B3
3791.72	Gd II-46	B3	3818.48	Cr I -40	
3792.34	Ni I -2		3818.78	Zr II-111	B2
3792.73			3819.10		
3793.48	Fe I -387	B1	3819.67	Eu II-1	B1
3793.87	Fe I -367	B1	3820.43	Fe I -20	B1
3793.88	Cr I -139	B1	3820.87	Cr I -40	
3794.34	Fe I -177	B1	3821.18	Fe I -608	B1
3794.61	Cr I -139		3821.58	Cr I -40	
3795.00	Fe I -21	B1	3821.92	P Fe II-14	B1
3795.54			3822.45		B3
3795.90	Ti I -115		3822.89	V I -28	B2
3796.37	Gd II-2		3823.51	Mn I -6	B1
3796.77			3824.07	Fe I -224	B2
3797.90	H -10		3824.18	Sm II-18	B2
3799.55	Fe I -21	B1	3824.44	Fe I -4	B1
3700.30	Pr II-uncl.		3824.91	Fe II-29	B1
3700.55	Mn I -45		3825.39	Cr I -70	B1
3701.21	Cr II-uncl.		3825.88	Fe I -20	B1
3701.68	Fe I -367	B1	3826.63	P Fe I -176	
3702.88	V I -67		3827.27	Zr II-uncl.	B2
3704.01	Fe I -702	B1	3827.82	Fe I -45	B1
3704.80	Cr I -139	B1	3828.56	V I -9	B1
3705.35	Fe I -608	B1	3829.35	Mg I -3	B1
3705.80			3829.68	Mn I -6	B1

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
3830.03	Cr I-uncl.	B2	3856.37	Fe I -4	B1
3830.53		B3	3857.03	Ce II-158	
3831.03	Cr I -24	B1	3857.26	P Y II-16	B1
3831.80	Gd II-3		3857.63	Cr I -69	B1
3832.30	Mg I -3	B1	3858.30	Ni I -32	B1
3832.94	Zr II-7	B3	3858.90	Cr I -138	B1
3835.39	H -9		3859.21	Fe I -175	B1
3836.76	Ti I-uncl.		3859.24	Mg I -21	B1
3838.29	Mg I -3	B1	3859.91	Fe I -4	B1
3839.00	V I -44	B3	3860.74	P Fe I -704	
3839.26	Fe I -529	B1	3861.34	Fe I -283	B1
3839.61	Fe I -995	B3	3861.95		
3839.64	Gd II-20	B1	3862.59	Si II-1	B1
3840.44	Fe I -20	B1	3863.07	Ni I -181	B2
3841.08	Mn I -6	B1	3863.41	Nd II-26	B1
3841.28	Cr I -69	B1	3863.75	Fe I -280	B1
3842.20	Gd II-uncl.	B1	3863.95	Fe I -127,152	B1
3843.03	Zr II-7	B1	3864.86	V I -7	B2
3843.26	Fe I -528	B1	3865.53	Fe I -20	B1
3843.80	Gd II-17		3866.01	Cr II-130	B1
3844.18		B2	3866.54	Cr II-130	B1
3844.58	Gd II-2	B1	3866.83		
3844.89	V I -44		3867.22	Fe I -488	B1
3845.21	P Fe I -701	B2	3867.93	Fe I -221	B1
3845.47	Co I -34	B1	3868.40	Ti I -175	
3845.69	Fe I -771	B1	3869.56	Fe I -284	B1
3846.00	Fe I -703	B2	3869.59	Fe I -284	B1
3846.41	Fe I -804	B1	3870.16		B2
3846.80	Fe I -664	B1	3870.87		B2
3847.41		B3	3871.75	Fe I -429	B1
3848.19	Y II-72		3872.13		B3
3848.52	Nd II-uncl.	B1	3872.55	Hf II-27	B3
3848.98	Cr I -69	B1	3873.20	Ti I -176	
3849.37	Cr I -138	B1	3873.76	Fe I -175	B1
3849.97	Fe I -20	B1	3874.48		B3
3850.40	Mg II-5	B1	3875.08	V I -7	B2
3850.82	Fe I -22	B1	3876.09	V I -8	B2
3852.10	V II-3		3876.97	Ce II-82	
3852.57	Fe I -73	B1	3877.30		
3853.16	Ce II-39	B1	3878.02	Fe I -20	B1
3853.18	Cr I -69	B1	3878.37	Ce II-48	
3853.66	Si II-1	B1	3878.66	Fe I -175	B1
3854.22	Cr I -69	B1	3879.22	Cr I -138	B1
3854.77			3879.96		
3855.29	Cr I -69	B1	3880.34		B3
3855.33	Fe I -283	B1	3881.21	Cr I -138	B1
3855.57	Cr I -69	B1	3881.87	Co I -18	B1
3856.02	Si II-1	B1	3882.28	P Ti II-34	B1

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
3882.89	Ti I -176	B1	3906.48	Fe I -4	B1
3883.28	Fe I -663	B1	3907.10	Eu II-5	B1
3883.29	Cr I -23	B1	3907.94	Fe I -280	B1
3883.58			3908.41	Ce II-65	B1
3883.97			3908.43	Pr II-11	B1
3884.36	Fe I -282	B1	3908.76	Cr I -23	B1
3884.66	Fe I -565	B1	3909.31	Ce II-133	B1
3885.22	Cr I -23	B1	3909.66	Fe I -565	B1
3885.51	Fe I -124	B1	3909.83	Fe I -364	B1
3886.28	Fe I -4	B1	3910.85	Fe I -284	B1
3887.05	Fe I -20	B1	3911.32	Cr II-129	B2
3889.05	H -8		3911.95	Cr I-uncl.	B2
3889.99	Ce II-50		3912.42	Ce II-60	B1
3890.53	Tm II-1		3912.66		
3890.84	Fe I -280	B1	3913.46	Ti II-34	B1
3890.94	Nd II-uncl.	B1	3914.27	Fe I -567	B3
3891.93	Fe I -733	B1	3914.42	P Fe I -652	
3892.98	Fe I -567	B1	3914.95	Ce II-78	B3
3893.39	Fe I -430	B1	3915.18		B2
3894.04	Cr I -23		3915.50	Co I -113	B1
3894.07	Co I -34	B1	3915.84	Cr I -136	B3
3894.34			3916.42	V II-10	B1
3894.63	Nd II-29	B1	3916.73	Fe I -606	B1
3894.70	Gd II-1	B1	3917.19	Fe I -20	B1
3895.24	Ti I -176	B1	3917.60	Cr I -137	B1
3895.66	Fe I -4	B1	3918.24	Gd II-50	B2
3896.16	V II-10	B1	3919.07	Fe I -430	B1
3896.80	Ce II-188	B1	3919.33		
3896.80	Y II-86	B1	3919.81	Ce II-60	
3897.45	Fe I -429	B1	3920.26	Fe I -4	B1
3898.01	Fe I -20	B1	3920.65	Fe I -153	B2
3898.28	V I-uncl.		3921.02	Cr I -23	B1
3899.04	Fe I -175		3921.73	Ce II-195	B1
3899.71	Fe I -4	B1	3922.01	Ce II-50	
3900.23	Nd II-uncl.	B1	3922.91	Fe I -4	B1
3900.55	Ti II-34	B1	3924.08	Mn I-uncl.	
3900.96	Ti I -15		3925.20	Fe I -567	B1
3901.78	Mo I -8	B3	3925.65	Fe I -364	B1
3902.25	V I -7		3926.00	Fe I -562	B1
3902.56	V I -43		3926.65	Cr I -313	
3902.95	Fe I -45	B1	3926.96		
3903.27	V II-11	B1	3927.43		
3903.90	Fe I -429	B1	3927.92	Fe I -4	B1
3904.34	Ce II-91		3928.64	Cr I -23	B1
3904.58			3929.21	Fe I -659	B3
3904.79	Ti I -56	B1	3929.88	Ti I -13	
3905.53	Si I -3	B1	3930.30	Fe I -4	B1
3906.04	Fe II-173	B1	3931.12	Fe I -565	B1

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
3931.37	Ce II-61		3950.35	Y II-6	B1
3932.01	Ti II-34	B1	3951.16	Fe I -661	B1
3932.95			3951.97	V II-10	B1
3933.66	Ca II-1	B1	3952.40	Cr I -136	B1
3934.80	Zr II-43	B1	3952.61	Fe I -278	B1
3935.31	Fe I -362		3953.16	Fe I -430	B1
3935.94	Fe II-173	B1	3953.66	Ce II-141	
3936.95	Cr II-128		3953.86	Fe I -362	B1
3937.33	Fe I -278	B1	3954.58		
3938.29	Fe II-3	B3	3955.35	Fe I -562	B1
3938.97	Fe I -190	B1	3955.96	Fe I -488	B1
3939.51	P Sc II-9	B3	3956.46	Fe I -604	B1
3940.34	Ce II-50	B1	3957.03	Fe I -562	B1
3940.88	Fe I -20	B1	3957.67	Gd II-19	B1
3941.28	Fe I -562	B1	3957.93	Co I -18	B1
3941.51	Nd II-27	B1	3958.21	Ti I -13	B3
3941.73	Co I -17	B1	3958.82		
3942.44	Fe I -364	B1	3959.52	Gd II-44	B1
3942.75	Ce II-57	B1	3959.78		B2
3943.14	Ce II-113	B2	3960.28	Fe I -913	B1
3943.48	P V II-11	B2	3960.91	Ce II-84	B1
3943.89	Ce II-234	B1	3961.57		B3
3944.89	Fe I -430	B1	3962.12	Ni I -199	B2
3945.12	Fe I -280	B2	3962.65	P Fe I -913	
3945.50	Cr I -135		3963.05		B3
3945.86			3963.69	Cr I -38	B1
3947.00	Fe I -561	B1	3964.16		
3947.53	Fe I -426,361	B1	3964.52	Fe I -361	B1
3948.11	Fe I -562	B1	3964.96	Hf II-54	
3948.78	Fe I -604	B1	3965.51	Fe I -565	
3949.10	La II-41	B1	3966.07	Fe I -45	B1
3949.95	Fe I -72	B1	3966.63	Fe I -282,562	
			3967.05	Ce II-84	B1
			3967.54		

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
3968.47	Ca II-1	B1	3997.49	Fe I -556	B1
3969.26	Fe I -43		3997.90	Co I -32	B1
3970.07	He		3998.19		H2
3971.98	Eu II-5	B1	3998.55	Co I -33	H3,B1
3973.14	Co I -58		3999.07	P Cr II-10	
3973.98	Gd II-50	B1	3999.68	Cr I-uncl.	H1,B1
3974.16	Fe II-29	B1	4000.10		
3974.55			4000.47	Fe I -426	H1,B3
3975.14			4000.89		
3976.18			4001.89		
3976.74			4002.55	Fe II-190	H1,B1
3977.95			4002.94	V II-9	H1,B1
3978.86	Co I -173	B1	4003.33	Cr II-194	H1,B1
3979.80	Cr I -67		4003.76	Fe I -728	H1,B1
3980.53			4004.15	P Fe II-127	H1
3981.11	Fe I -22		4005.25	Fe I -43	H1,B1
3981.47	Ti I -188		4005.60		
3982.00	Ti II-11	H1,B1	4005.87		
3982.59	Y II-6	H1,B1	4006.49		
3982.90	Ce II-172	H1	4006.88		
3983.24	Cr I -213	H1	4007.20	Ti I -187	
3983.55		H3,B3	4007.44	Nd II-uncl.	B1
3984.18	Mn I -23	B1	4007.72	P Fe II-189	
3984.60	V I -89		4008.05	Ti I -187	H2
3984.93	P Fe I -561	H2,B2	4008.99		
3985.69		H2,B2	4009.19		H3,B3
3986.48		H3	4009.71	Fe I -72	H1,B1
3987.10	Mn I -33	H1,B1	4010.18	Fe I -915	H2,B1
3987.46	Mn I -33	B1	4010.58		H2,B2
3987.95		H2	4010.77	Fe I -219,320	B2
3988.51	La II-40	H1,B1	4011.53	Ti I -10	
3988.83	V I -89		4012.37	Ti II-11	H1,B1
3989.44	Ce II-240	H1,B2	4012.70	Nd II-uncl.	B1
3990.38	Fe I -527	H1,B1	4013.80	Fe I -485	H1
3990.83			4014.53	Fe I -802	H1,B1
3991.12	Cr I -38	H1,B1	4014.90	Ce II-157	H1,B1
3991.14	Zr II-30	H1,B1	4015.59		H2,B2
3991.53	Co I -173	B1	4016.43	Fe I -560	H1,B1
3992.11	Cr I -38	H1,B2	4017.16	Fe I -527	H1,B1
3992.73			4017.56	Ni I -171	B2
3993.31	Sm II-4	B3	4018.10	Mn I -5	H1,B1
3993.62			4018.28	Fe I -560	H1,B1
3994.56	P Ti I -186	H3,B3	4019.05	Fe I -219	H3,B2
3995.05		B2	4019.30	P Co I -18	H3,B1
3995.74	La II-27	B1	4020.27		H2,B2
3996.52	Tm II-uncl.		4020.49	Fe I -913	H1,B2
3996.79	P Fe I -1074	H3,B2	4020.90	Co I -16	H1,B1
3997.39	Fe I -278	H1,B1	4021.43		H3

TABLE III (Continued)

λ RMT	Ident.	Code	λ RMT	Ident.	Code
4021.87	Fe I -278	H1,B1	4049.86	Gd II-uncl.	H1,B1
4022.26	Cr I -268	B1	4050.67	Hf II-59	H3,B3
4022.74	Fe I -556	H1,B1	4051.34	V II-215	H1,B1
4023.39	V II-32	H1,B1	4051.97	Cr II-19	H1,B1
4023.74	Cr I -268	H3,B1	4052.47	Mn I -48	H1,B2
4024.11	Fe I -277	H1,B1	4053.45	Cr II-19	H1,B1
4024.55	Fe II-127	H1,B1	4053.82	Fe I -485	H1,B3
4025.14	Ti II-11	H1,B1	4054.11	Cr II-19	H1,B1
4025.44	Cr I -37	H2,B1	4054.88	Fe I -698	H1,B1
4025.87	La II-42	H1,B2	4055.54	Mn I -5	H1,B1
4026.17	Cr I -37	H1,B1	4056.07	Cr II-182	H1,B1
4027.10	Cr I -37	H1,B1	4056.79	Cr I -306	H1
4027.95		H3	4057.46	Fe II-212	H1
4028.41	Ce II-47	H1,B3	4057.51	Mg I -16	H1,B1
4029.68	Zr II-41	H1,B2	4057.81	Cr I -251	H3
4030.47	Nd II-32	H3	4058.23	Fe I -558	H1,B1
4030.50	Fe I -560	H1,B1	4058.77	Cr I -251	H1,B1
4030.76	Mn I -2	H1,B1	4058.77	Fe I -120	H1,B1
4031.35	Zr II-42	H1,B3	4059.39	Mn I -29	H3,B1
4031.97	Fe I -655	H1,B1	4059.73	Fe I -767	H1,B1
4032.64	Fe I -44	H1,B2	4060.62	Cr I -156	
4033.07	Mn I -2	H1,B1	4061.09	Nd II-10	H1,B1
4033.72			4061.74	Mn I -29	H1,B1
4034.10	Zr II-42	H1,B1	4062.45	Fe I -359	H1,B1
4034.49	Mn I -2	H1,B1	4063.29	Fe I -698	H1,B1
4035.63	V II-32	H1,B1	4063.60	Fe I -43	H1,B1
4036.31		H3	4064.07	P Fe I -423	H3,B1
4037.33	Gd II-49	H1,B1	4064.35	Ti II-106	H1,B1
4037.67	Ce II-218	H1,B1	4064.75	P Fe II-39	
4038.03	Cr II-194	H1,B1	4065.07	V II-215	H1,B1
4038.35		H2	4065.40	Fe I -698	H1,B1
4038.81		H3,B2	4065.72	Cr I -279	H1,B1
4039.10	Cr I -251	H1,B1	4066.16	P Cr II-182	H1,B1
4039.57	V II-32	H1,B1	4066.60	Fe I -424	H1,B2
4039.94	Fe I -276	H1,B1	4066.98	Fe I -358	H1,B1
4040.65	Fe I -655	H1,B1	4067.28	Fe I -217	H1,B1
4041.29	Fe I -603,654	H1,B3	4067.98	Fe I -559	H1,B1
4041.64	P Fe II-127	H1,B2	4068.54	Co I -58	H2,B1
4042.14	Ce II-252	H1	4068.84	Ce II-82	H1,B1
4042.64	V I -96	H3	4069.66		H2,B2
4043.90	Fe I -276,557	H1,B1	4070.03	P Fe II-22	H1,B2
4044.01	P Fe II-172	H1,B1	4070.28	Mn I -5	H1,B1
4044.61	Fe I -359	H1,B1	4070.29	Gd II-49	H1,B1
4045.21	Mn I-uncl.	H3,B2	4070.77	Fe I -558	H1,B1
4045.82	Fe I -43	H1,B1	4070.77	Fe I -43	H1,B1
4046.34	Ce II-81	H1,B1	4071.74	Fe I -698	H1,B1
4046.81	P Fe II-126	H1,B3	4072.52	Cr II-26	H1,B1
4047.32	Fe I -117,853	H1,B1	4072.56	Ni I -197	H2,B2
4047.79	Sc I -7	H1,B3	4072.91		
4048.83	Fe II-172	H1,B1			
4049.14	Cr II-193	H1,B1			
4049.43	Gd II-50	H1,B1			

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4073.20	Gd II-34	H1, B1	4099.02	Cr I -108	
4073.76	Fe I -558	H1, B1	4099.77	Mg I -46	H3
4074.15		H2	4101.74	H δ	H1
4074.79	Fe I -524	H1, B1	4102.26		H3
4075.12	Nd II-62	H1, B1	4103.22		H3, B3
4075.92	Cr I -66	H3, B2	4104.13	Fe I -558	H1, B1
4076.23	Fe I -486	H1, B1	4104.97	Fe I -694	H1, B1
4076.87	Cr II-19	H1, B1	4105.84	Tm I-uncl.	H3, B2
4077.71	Sr II-1	H1, B1	4106.13	Ce II-160	H1
4078.44	Gd II-15	H1, B1	4106.88	Ce II-139	H1
4079.24	Mn I-5	H1, B1	4107.49	Fe I -354	H1, B1
4079.71	Ti I-207		4107.77		H3, B2
4080.23	Fe I-558	H1, B1	4108.55	Ca I -39	H1, B1
4080.89	Fe I-557	H1, B1	4109.07	Nd II-17	H1, B1
4081.22	Ce II-4	H1, B2	4109.58	Cr I -65	H1, B2
4081.74	Cr I -66		4109.81	Fe I -357	H1, B1
4082.30	Cr II-165	H1, B1	4110.38	Ce II-29	H1
4082.94	Mn I -5	H1, B1	4110.53	Co I -29	B1
4083.23	Ce II-60	H1, B1	4111.01	Cr II-18, 26	H1, B1
4083.63	Mn I -5	H1, B1	4111.39	Ce II-uncl.	H1, B2
4084.50	Fe I -698	H1, B1	4111.79	V I -27	H3, B1
4085.01	Fe I -358	H1, B1	4111.90	Fe II-188	H1
4085.31	Fe I -559	H1, B1	4112.59	Cr II-18	H1, B2
4086.14	Cr II-26	H1, B1	4112.97	Fe I -1103	H1, B1
4086.43		H3	4113.24	Cr II-18	H1, B1
4086.72	La II-10	H1, B1	4113.73	Ce II-137	H1
4087.10	Fe I -694	H1, B1	4114.15		H3, B2
4087.63	Cr II-19	H1, B1	4114.45	Fe I -357	H1, B1
4088.90	Cr II-19	H1, B2	4114.96	Fe I -695	H1, B1
4089.49	Cr II-164	H1, B2	4115.37	Ce II-22	H1, B1
4089.77		H3	4115.89	P Fe I -910	H1, B2
4090.09	Fe I -700	H1	4116.66	Cr II-181	H1, B2
4090.52	Zr II-29	H1, B1	4116.97	Fe I -558	H1, B1
4090.98	Fe I -695	H3, B1	4117.01	Ce II-35	H1, B1
4091.56	Fe I -357	H1, B1	4117.29	Ce II-77	H1
4092.17	Cr I -180		4117.61		H3, B2
4092.63	Ca I -25	H1, B1	4117.87	Fe I -700	H1, B1
4093.16	Hf II-6		4118.14	Ce II-11	H1, B1
4093.90	Mg II-29		4118.62		H3, B3
4093.96	Ce II-160		4118.90	Fe I -559	H1, B1
4094.48	Gd II-48	H1, B1	4119.44	Cr I -65	H3
4094.93	Ca I -25	H1, B1	4119.78	Ce II-22	H1
4095.27	P Fe I -1075	H1	4119.88	Ce II-83	H1, B2
4095.98	Fe I -217	H1, B1	4120.21	Fe I -423	H1, B1
4096.82	Pr II-29	H3	4120.83	Ce II-112	H1, B1
4097.10	Fe I -558	H1, B1	4121.32	Co I -28	H1, B1
4098.09		H3	4121.81	Fe I -356	H1, B1
4098.53	Ca I -25	H1, B1	4122.64	Fe II-28	H1, B1

TABLE III (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4123.39	Cr I -108	B2	4147.26	P Fe II-141	H3,B1
4123.49	Ce II-22	H1,B1	4147.67	Fe I -42	H1,B1
4123.87	Ce II-60	H1,B1	4148.19		H3
4123.88	Nd II-65	B1	4148.90	Ce II-28	H1,B1
4124.79	Fe II-22	H1,B1	4149.37	Fe I -694	H1,B1
4125.62	Fe I -1103	H1,B1	4149.94	Ce II-158,189	H1,B2
4126.19	Fe I -695	H1,B1	4150.26	Fe I -695	H1,B1
4126.52	Cr I -35	H1,B1	4151.00	Cr II-163	H1,B2
4127.08	Cr II-181	H1,B1	4151.60	P Fe II-149	H3
4127.30	Cr I -35	H1,B1	4152.07	P Fe I -1049	H3,B2
4127.37	Ce II-4	H1,B1	4152.78	Cr I -261	H1,B1
4127.72	Gd II-117	H1	4153.07	Cr I -35	H1,B1
4128.14	Mn II-2	H1,B1	4153.91	Fe I -695	H1,B1
4128.42		H3,B2	4154.50	Fe I -355	H1,B1
4128.74	Fe II-27	H1,B1	4154.81	Fe I -694	H1,B1
4129.21	Cr I -97	H3,B1	4155.22	Sm II-8,50	H1,B1
4129.73	Eu II-1	H1,B1	4155.93		H2
4130.37	Gd II-19,49	H1,B1	4156.27	Nd II-14	H3,B3
4130.88	Si II-3	H1,B1	4156.67	Fe I -419	B1
4131.45		H3,B3	4157.05		
4132.06	Fe I -43	H1,B1	4157.79	Fe I -695	B1
4132.41	Cr II-26	H1,B1	4158.33		H3
4132.90	Fe I -357	H1,B1	4158.80	Fe I -695	H1,B1
4133.80	Ce II-4	H1,B1	4159.15		H3,B2
4134.43	Fe I -482,697	H1,B2	4160.12		H2,B2
4134.68	Fe I -357	H1,B1	4160.41		H3,B2
4135.12		H3,B2	4161.18	Ce II-22	H1,B3
4135.44	Ce II-188	H1,B2	4161.49	Fe I -422	H3,B2
4135.77	Fe I -1073	H3,B1	4161.80	Sr II-3	H1,B1
4136.51	Fe I -694	H1,B1	4162.73	Gd II-17	H1,B1
4137.00	Fe I -726	H1,B1	4163.64	Ti II-105	H1,B1
4137.42	Fe I -1103	H1,B1	4164.74		H2
4138.40	P Fe II-39	H1,B2	4165.52	Cr I -305	H1
4139.04		H2,B2	4165.81		H2
4139.45	Co I -94	H3,B2	4166.20		H3
4139.76		H3,B2	4166.64		H3
4140.44	Fe I -694,695	H1,B1	4166.85		H3
4141.02	Gd II-117	H1,B2	4167.27	Mg I -15	H1,B1
4141.86	Fe I -422	H1,B2	4167.86	Fe I -399	H1
4142.47	Cr I -179	H3,B3	4168.63	Fe I -689	H1,B1
4142.86	Y I -5	H2,B2	4168.94	Fe I -694	H1,B1
4143.42	Fe I -523	H1,B1	4169.84	Cr I -278	H1,B2
4143.87	Fe I -43	H1,B1	4170.20	Cr I -278	H1,B1
4144.49	Ce II-3	H1,B1	4170.58	P Cr II-18	H1,B2
4145.00	Ce II-9	H1,B2	4171.02	Ti I -206	H3,B2
4145.77	Cr II-162	H1,B1	4171.90	Ti II-105	H1,B1
4146.23	Ce II-203	H1,B1	4172.64	Fe I -689	H3,B1
4146.70	Cr I -107	H1,B1	4173.45	Fe II-27	H1,B1

TABLE III (Concluded)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4173.93	Fe I -19	H1, B2			
4174.31	P Mn II-2	B1			
4174.80	Cr I -241	H1, B1			
4175.23	Cr I -261	H3, B1			
4175.61	Nd II-39	H3, B3			
4175.89	P Fe I -694	H1			
4176.57	Fe I -695	H1, B1			
4177.60	Fe I -18	H1			
4178.86	Fe II-28	H1, B1			
4179.26	Cr I -179, 250	H1, B1			
4179.86	Ti I -206	H3, B3			
4181.08					

TABLE IV
LINE IDENTIFICATIONS FOR $\lambda\lambda 4187-4636$

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4187.80	Fe I -152	H1,B1	4207.13	Fe I -352	H1,B1
4188.69	Ti I -220	H2,B2	4207.35	Cr II-26	H1,B1
4189.56	Fe I -940	H3,B1	4207.81		H2,B2
4190.16	Cr I -84	H1,B1	4208.36	Cr I -249	H1,B1
4190.66	Cr I -35	H1,B3	4208.61	Fe I -689	H1,B1
4191.07	Gd II-34	H1,B1	4209.02	Cr II-162	H1,B3
4191.44	Fe I -152	H1,B1	4209.37	Cr I -248	H1,B1
4192.10	Cr I -273	H3,B1	4209.84	P Cr II-180	H1,B2
4192.35	La II-78	H1	4210.35	Fe I -152	H1,B1
4192.72		H2,B2	4211.02		H2,B2
4193.09	Ce II-79	H1,B1	4211.35	Cr I -133	H1,B1
4193.66	Cr I -248	H1,B1	4211.88	Zr II-15	H1,B1
4193.87	Ce II-85	H1,B1	4212.00	Gd II-15	H1,B1
4194.50	P Fe I -274	H3,B2	4212.66		H3
4194.95	Cr I -248	H1,B1	4213.04	Ce II-169	H1,B2
4195.34	Fe I -693	H1,B1	4213.65	Fe I -355	H1,B1
4195.83	V II-19	H3,B2	4214.04	Ce II-203	H1
4196.22	Fe I -693	H1,B1	4215.02	Gd II-32	H1,B1
4196.55	La II-41	H1,B1	4215.52	Sr II-1	H1,B1
4197.23	Cr I -249	H1,B1	4215.77	Cr II-18	H1,B1
4197.68	Gd II-uncl.	H1,B1	4216.19	Fe I -3	H1,B1
4198.10		H2,B2	4217.07	Cr II-18	H1,B2
4198.31	Fe I -152	H1,B3	4217.20	Gd II-49	H1,B2
4198.65	Fe I -693	H1,B1	4217.55	Fe I -693	H1,B1
4199.10	Fe I -522	H1,B1	4218.18	P Ti II-33	H1,B2
4199.47		H2	4219.36	Fe I -800	H1,B1
4199.92	Tm II-1	H1,B2	4219.66		H3
4200.10	Cr I-uncl.	H1,B1	4220.05	V II-25	H1,B1
4200.40	P Ti II-96	H1	4221.57	Cr I -155	H1,B1
4200.93	Fe I -689	H1,B1	4222.00	Cr II-180	H1,B2
4201.29		H3	4222.22	Fe I -152	H1,B1
4202.03	Fe I -42	H1,B1	4222.60	Ce II-36	H1
4202.52		H3,B3	4223.02	Gd II-141	H1
4202.76	Fe I -476a	H1,B1	4224.18	Fe I -689	H1
4202.94	Ce II-186	H1,B1		Fe I -689	
4203.59	Cr I -35	H1,B1		V II-25	
4203.99	Fe I -355	H1,B1	4224.51	Cr I -155	H1
4204.47	Cr I -272	H2,B1	4224.85	Cr II-162	H1,B1
4205.05	Eu II-1		4225.46	Fe I -693	H1,B1
4205.08	V II-37	H1,B1	4225.68		H3,B2
4205.37	P Mn II-2	H1,B1	4225.96	Fe I -521	H1,B1
4205.55	Fe I -689	H1,B1	4226.43	Fe I -352	H1,B1
4205.85		H3	4226.73	Ca I -2	H1,B1
4206.21	Ca II-16	H1,B3	4227.43	Fe I -693	H1,B1
4206.38	Mn II-7	H1,B1	4227.72	Nd II-19	H1,B1
4206.90	Cr I-uncl.	H1,B1	4227.73	Cr II-155	H1,B3

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4227.75	Ce II-8	H1,B1	4249.44		H3
4228.33		H3,B1	4250.13	Fe I -152	H1,B1
4228.79		H3,B2	4250.79	Fe I -42	H1,B1
4229.52	Fe I -649	H3,B1	4251.41		H3
4229.80	Gd II-117	H1,B1	4251.73	Gd II-15	H1,B1
4230.12		H2	4252.05	P Ti II-95	H1
4230.48	Cr I -132	H1,B1	4252.24	Cr I -131	H1
4231.04	Ni I -136	H3,B1	4252.62	Cr II-31	H1,B1
4231.35	C I -17	H2	4253.02	Mn II-7	H1,B2
4231.95		H3,B2	4253.36	Ce II-77	H1,B1
4232.46	V I -111	H3,B3	4253.37	Gd II-46	H1,B1
4233.17	Fe II-27	H1,B1	4253.61	Gd II-uncl.	H1,B1
4233.25	Cr II-31	H1,B1	4253.93	P Fe I -905	H1,B2
4233.61	Fe I -152	H1,B1	4254.35	Cr I -1	H1,B1
4234.20	Nd II-20	H3,B1	4254.94	Fe I -419	H1,B1
4234.52	Cr I -178	H3,B1	4255.50	Cr I -105	H3,B1
4234.55	V II-200	H1,B1	4255.78	Ce II-81	H1,B1
4234.57	Sm II-42	H1,B1	4256.16	Cr II-192	H1,B1
4235.14	Mn I -23	H1,B1	4256.72		H3,B2
4235.94	Fe I -152	H1,B1	4257.12	Ce II-123	H1
4236.37	Ni I -237	H3,B2	4257.37	Cr I -131	H1,B1
4237.16	Fe I-uncl.	H1,B1	4258.16	Fe II-28	H1,B1
4238.03	Fe I -689	H1,B1	4258.87		B3
4238.79	Mn II-2	H1,B1	4259.15	Cr I -131	H1,B1
4238.82	Fe I -693	H1,B1	4259.75	Ce II-176	H1
4239.31	Zr I -45	H3,B1	4259.99	Fe I -689	H1,B1
4239.36	P Fe I -907	H1	4260.14	Fe I -476a	H1
4239.73	Mn I -23	H1,B1	4260.48	Fe I -152	H1,B1
4239.85	Fe I -273	H1,B1	4261.26		H3,B3
4240.37	Fe I -764	H1,B2	4261.92	Cr II-31	H1,B2
4240.71	Cr I -105	H1,B1	4262.68	Sm II-37	H1,B1
4241.11	Fe I -351	H3,B2	4263.14	Cr I -247	H1,B1
4241.59			4263.90	Fe II-uncl.	H1
4242.38	Cr II-31	H1,B1	4264.21	Fe I -692	H1,B1
4242.73	Fe I -649	H3,B1	4264.74	Fe I -993	H1,B1
4243.37	Fe I -906	H1,B1	4265.26	Fe I -993	H1,B1
4243.79	Fe I -994	H3,B1	4265.92	Mn I -23	H1,B1
4244.26	Mn II-7	H1,B1	4266.97	Fe I -273	H1,B1
4244.53	P Fe II-12	H1	4267.30	P Zr II-132	H1
4244.80	Ni II-9	H1	4267.83	Fe I -482	H1,B1
4245.26	Fe I -352	H1,B1	4268.34		H3
4245.92		H3	4268.74	Fe I -649	H1,B1
4246.41	Cr II-31	H1,B1	4269.28	Cr II-31	H1,B1
4246.83	Sc II-7	H1,B1	4269.95	Cr I -154	B1
4247.43	Fe I -693	H1,B1	4270.19	Ce II-204	H1,B1
4248.23	Fe I -482	H1,B1	4270.72	Ce II-21	H1
4248.68	Ce II-1	H1,B1	4271.16	Fe I -152	H1,B1
4249.01		H3,B2	4271.76	Fe I -42	H1,B1

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4272.27	Pr II-15	B2	4294.13	Fe I -41	H1,B1
4272.44	Ti I -44	H1,B2	4294.77	Sc II-15	H1,B1
4272.91	Cr I -96	H1,B1	4295.28		H3
4273.32	Fe II-27	H1,B1	4296.08	Gd II-46	H1,B1
4273.71		H2	4296.57	Fe II-28	H1,B1
4273.95		H2,B3	4297.17	Gd II-uncl.	H1,B1
4274.80	Cr I -1	H1,B1	4297.74	Cr I -247	H1,B1
4275.57	Cr II-31	H1,B1	4298.04	Fe I -520	H1,B1
4275.97	Cr I -240	H3,B1	4299.24	Fe I -152	H1,B1
4276.27		H3	4300.05	Ti II-41	H1,B1
4276.68	Fe I -976	H1,B1	4300.52	P Ti I -205	H3,B2
4277.55			4300.83	Fe I -976	H3,B1
4277.68	Fe I -172	H2	4301.09	Ti I -44	H1,B1
4278.13	Fe II-32	H1,B1	4301.18	Cr I-uncl.	H1,B1
4278.83	Ti I -252	H3	4301.50		
4279.11		H2	4301.93	Ti II-41	H1,B1
4279.48	Fe I -993	H1,B1	4302.53	Ca I -5	H1,B1
4280.49	Gd II-15	H1,B1	4303.17	Fe II-27	H1,B1
4280.41	Cr I -247	H3,B1	4303.57	Nd II-10	H1,B1
4281.10	Mn I -23	H1,B1	4304.20		H3
4281.48		H3	4304.90	Gd II-uncl.	H1,B1
4281.97		H3,B2	4305.13	P Fe I -272	H3,B3
4282.41	Fe I -71	H1,B1	4305.20	Fe I -760	B1
4282.77		H3	4305.45	Sr II-3	H1,B1
4283.01	Ca I -5	H1,B1	4306.34	Gd I -4	H1
4283.40	P Fe I -215	H2	4306.72	Ce II-1	H1,B1
4283.77	Mn II-6	H1,B1	4306.95	Ti I -43	H3,B1
4284.21	Cr II-31	H1,B1	4307.74	Ca I -5	H1,B1
4284.68	Ni I -86	H3	4307.90	Ti II-41	H1,B1
4284.99	Ti I -148	H3,B2	4307.91	Fe I -42	H1
4285.45	Fe I -597	H1,B1	4308.13		H3
4286.31	Fe II-uncl.	H1,B2	4308.82		H3
4286.98	Fe I -976	H1,B2	4309.04	Fe I -849	H1,B2
4287.89	Ti II-20	H1,B1	4309.38	Fe I -414	H1,B1
4288.15	Fe I -273	H1,B1	4309.62	Y II-5	H1,B1
4288.34		H3,B2	4310.37	P Fe I -994	H1,B2
4288.65	Mo I -7	H3	4310.37	Ti I -79	H1,B2
4288.96	Fe I -214	H1,B2	4310.98	Gd II-15	H1,B2
4289.36	Ca I -5	H1,B1	4311.57		H2,B2
4289.72	Cr I -1	H1,B1	4311.99		
4290.22	Ti II-41	H1,B1	4312.86	Ti II-41	H1,B1
4290.87	Fe I -351	H1,B1	4314.08	Sc II-15	H1,B1
4291.47	Fe I -3	H1,B1	4314.29	Fe II-32	H1,B1
4291.96	Cr I -240	H1,B1	4314.98	Ti II-41	H1,B1
4292.25	Mn II-6	H1,B1	4315.09	Fe I -71	H1,B1
4292.77	Ce II-205	H1	4315.47		H2
4293.46		H3	4316.05	Gd II-43	H1,B1
4294.10	Ti II-20	H1,B1	4316.81	Ti II-94	H1,B1

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4317.32	Zr II-40	H1,B1	4345.96	Ce II-251	H1
4317.65		H3	4346.50	P Fe II-202	
4317.97			4346.56	Fe I -598	H1,B1
4318.22	Fe II-220	H1	4347.31	Gd II-103	H1,B1
4318.65	Ca I -5	H1,B1	4347.80	Sm II-37	H1,B1
4319.64	Cr I -96	H1,B1	4348.31		H3,B2
4320.13	P Fe I -1170	H2	4348.94	Fe I -414	H1
4320.75	Sc II-15	H1,B1	4349.46		H3
4321.66	Ti I -235	H1	4349.79	Ce II-59	H1
4322.20	Gd II-15	H1,B2	4350.47	Sm II-46	H1,B1
4322.70	P Fe I -215		4351.00		H3
4323.44	Ti I -79	H3	4351.76	Fe II-27	H1,B1
4324.06	Gd II-68	H1,B2	4352.74	Fe I -71	H1,B1
4325.01	Sc II-15	H1,B1	4353.45		H2
4325.77	Fe I -42	H1,B1	4353.98	Cr I -198	H1,B1
4326.64	Mn II-6	H1,B1	4354.40	La II-58	H1,B1
4326.76	Fe I -413	H1,B3	4355.09	Eu II-22	
4327.10	Fe I -761	H1,B1	4355.10	Ca I -37	H1,B1
4327.13	Gd II-15	H1,B1	4355.94	V I -5	H2,B3
4327.92	Fe I -597	H3,B1	4356.76	Cr I -130	H1,B1
4328.17		H2	4357.13		H2,B2
4328.91	P Cr II-37	H1	4357.57	Fe II-uncl.	H1,B2
4329.90		H2,B2	4358.51	Fe I -412	H1,B1
4330.26	Ti II-94	H1,B1	4358.95	P Fe I -987	
4330.71	Ti II-41	H1,B1	4359.12	P Fe II-202	H3
4331.79	V II-23	H3	4359.63	Cr I -22	H1,B1
4332.57	Cr I -176	H1,B1	4360.03	P Fe II-148	H3
4332.88	P Fe II-33	H2	4360.49	Ti I -204	H1
4333.76	La II-24	H1,B1	4360.81	Fe I -903	H3,B1
4334.29		H2	4361.25	Fe II-uncl.	H1,B2
4334.77	P V II-36	H3	4361.61		H3,B2
4335.42		H2	4361.91	Co I -1	B2
4336.26	Ce II-89	H1	4362.42		H2
4336.74			4362.95	Cr I -82	H3,B2
4337.05	Fe I -41	H1,B1	4363.13	Cr I -103	B1
4337.33	Ti II-94	H1	4363.45		H3,B3
4337.57	Cr I -22	H3,B1		Cr I -130	B1
4337.92	Ti II-20	H1,B1	4364.14	Gd II-33	H1
4338.70	P Fe II-32	H1	4364.66	Ce II-135	H1,B1
4339.41		H3	4365.56		H2
4340.47	H Y	H1,B1	4365.90	Fe I -415	H2,B1
4341.37	Ti II-32	H1	4366.17	Fe II-216	
4342.23	Zr II-98	H3,B3	4366.51		H2
4342.53		H2	4366.97		H3
4343.99	Mn II-6	B1	4367.31		H3
4344.29	Ti II-20	H1,B1	4367.66	Ti II-104	H1,B1
4344.30	Gd II-44	H1,B1	4368.03		H1
4344.49	Gd II-31	H1	4368.25	Cr I -130	H3,B1

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4368.78			4389.71		H3
4369.40	Fe II-28	H1,B1	4390.59	Mg II-10	H1,B1
4369.77	Fe I -518	H1,B1	4390.95	Fe I -414	H1,B1
4370.33		H3,B2	4390.98	Ti II-61	H1,B1
4370.76		H2	4391.34		H3
4371.28	Cr I -22	H1,B1	4391.75	Cr I -22	H1,B1
4371.81		H2	4392.58	Fe I -973	H2,B1
4372.22	P Fe II-33	H1,B2	4393.20		H3
4373.25	Cr I -22	H1,B1	4393.53	Cr I -102	H1
4373.56	Fe I -214,413	H1,B2	4394.06	Ti II-51	H1,B1
4374.16	Cr I -104	H1,B2	4394.74		H3,B2
4374.46	Sc II-14	H1,B1	4395.03	Ti II-19	H1,B1
4374.94	Y II-13	H1,B1	4395.85	Ti II-61	H1,B1
4375.33	Cr I -103	H3,B1	4396.52		H3
4375.93	Fe I -2	H1,B1	4397.25	Cr I -129	H2
4376.31			4397.27	Fe II-33	H2
4376.78	Fe I -471	H1,B1	4398.02	Y II-5	H1,B1
4376.80	Cr I -304	H1,B1	4398.31	Ti II-61	H1,B1
4379.33	Fe I -990	B1	4398.79	Ce II-81	H1,B2
4377.55	Cr I -83	H1,B1	4399.20	Ce II-81	H1,B1
4378.24	Sm II-53	H1,B1	4399.77	Ti II-51	H1,B1
4379.01		H2	4400.36	Sc II-14	H1,B1
4379.78	Zr II-88	H1,B1	4401.29	Fe I -828	H1,B1
4380.06	Ce II-155	H2,B1	4401.97		
4380.64	Gd II-68	H1,B3	4403.08		H3,B2
4381.11	Cr I -64	H1,B1	4403.35	Zr II-79	H1,B1
4382.17	Ce II-2	H1,B1	4403.36	Sm II-22	H1,B3
4382.55		H3,B2	4403.96		
4382.78	Fe I -799a	H1,B1	4404.75	Fe I -41	H1,B1
4383.12	Gd II-67	H1,B1	4405.23	Ba II-16	H3
4383.55	Fe I -41	H1,B1	4405.40	P Fe I -991	H3
4384.13	Fe I -1101	H2,B2	4406.67	Gd II-103	H1,B1
4384.33	P Fe II-32	H1,B1	4407.17		
4384.72	V I -22	H3,B1	4407.68	Ti II-51	H1,B1
4384.98	Cr I -22	H1,B1	4407.71	Fe I -68	H1,B1
4385.38	Fe II-27	H1,B1	4408.42	Fe I -68	H1,B3
4386.34		H2	4408.25	Gd II-44	H1,B1
4386.86	Ti II-104	H1,B1	4408.84	Pr II-4	H1,B1
4387.50	Cr I -103	H1,B1	4409.22	Ti II-61	H1,B1
4387.90	Fe I -476	H1,B1	4409.52	Ti II-61	H1,B1
4388.41	Fe I -830	H1,B1	4409.84	Mg I -48	H2,B2
4389.12	P V II-13	H3,B3	4410.30	Cr I -129	H1,B1
			4410.64	Ce II-33	H1,B1
			4411.08	Ti II-115	H1,B1
			4411.94	Ti II-61	H1,B1
			4412.25	Cr I -22	B1
			4413.14		
			4413.60	Fe II-32	H1,B1

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4413.87	Cr I -234	H1,B1	4431.63	Fe II-222	H1,B2
4414.43	Nd II-3	H3,B3	4432.09	Ti II-51	H1,B1
4414.88	Mn I -22	H2,B1	4432.18	Cr I -81	H1,B1
4415.13	Fe I -41	H1,B1	4432.73		H3,B2
4415.56	Sc II-14	H1,B1	4433.22	Fe I -830	H1,B1
4416.09		H2	4433.79	Fe I -825	H1,B1
4416.82	Fe II-27	H1,B1	4434.32	Sm II-36	H1,B1
4417.72	Ti II-40	H1,B1	4434.96	Ca I -4	H1,B1
4418.34	Ti II-51	H1,B1	4435.58	Eu II-4	H1,B1
4419.03	Gd II-15	H3,B1	4436.23	Gd II-117	H1,B2
4419.67		H3,B2	4436.93	Fe I -516	H1,B1
4420.28		H2	4437.61	Ce II-169	H1
4421.14	Sm II-37	H1,B1	4438.27	Gd II-44	H1,B1
4421.24	Gd II-103	H1,B1	4439.26		H3
4421.95	Ti II-93	H1,B1	4440.08		
4422.59	Y II-5	H3,B1	4440.45	Zr II-79	H3,B1
4422.57	Fe I -350	H1,B1	4440.84	Fe I -992	H3,B1
4423.22	P Ti II-61	H1,B2	4441.73	P Ti II-40	H1,B2
4423.68	Ce II-21	H1	4442.34	Fe I -618	H1,B1
4424.28	Cr I -129	H1,B1	4442.84	Fe I -69	H3,B1
4425.44	Ca I -4	H1,B1	4443.20	Fe I -350	H1,B1
4426.24		H3	4443.80	Ti II-19	H1,B1
4427.31	Fe I -2	H1,B1	4444.56	Ti II-31	H1,B1
4427.92	Ce II-171	H1	4445.26	P Fe II-9	H1
4428.50	Cr I -129	H1,B1	4446.25	Fe II-187	H1,B1
4429.24	Pr II-4	H1,B1	4446.49	Gd II-14	H1
4429.27	Ce II-19	H1,B1	4446.76		H3,B3
4430.02	Ti II-267	H3	4447.72	Fe I -68	H1,B1
4430.20	Fe I -472	H3,B1	4448.22		H2
4430.51	P Cr I -128	H1	4449.34	Ce II-202	H1,B1
4430.77		H3	4449.66	Fe II-222	H1,B3
			4450.49	Ti II-19	H1,B1
			4450.77	P Fe I -972	H3
			4451.59	Mn I -22	H1,B1
			4451.98	Nd II-6	H1,B1
			4452.62	P Fe I -969	H2
			4453.12		
			4453.35	V II-199	H1,B1
			4453.93	Gd II-64	H1,B2
			4454.38	Fe I -350	H1,B1
			4454.78	Ca I -4	H1,B1

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4455.01	Mn I -28	H3,B1	4472.92	Fe II-37	H1,B1
4455.03	Fe I -974	H1,B1	4473.78	Cr I -63	H1,B1
4455.32	Mn I -28	H3,B1	4474.19	Fe II-171	H1,B1
4455.89	Ca I -4	H1,B1	4474.71	V I -101	H3
4456.39	Nd II-50	B1	4474.85	Ti I -113,184	
4456.61	Ca I -4	H1,B1	4475.35	Cr I -95	H1,B1
4457.42	Zr II-79	H1,B1	4476.08	Fe I -830	B2
4457.55	Mn I -28	H3,B1	4476.02	Fe I -350	H1,B1
4457.76	V I -101	H2	4476.50		H2
4458.10	Fe I -992	H3,B1	4477.08		H3
4458.26	Mn I -28	B1	4477.45	Y I-14	H2,B3
4458.54	Cr I -127	H1,B1	4478.66	Sm II-uncl.	H1,B1
4459.12	Fe I -68	H1,B1	4478.80	Gd II-15	H1,B1
4459.74	Cr I -127	H1,B1	4479.36	Ce II-203	H1,B3
4460.21	Ce II-2	H1,B1	4479.61	Fe I -828	H1,B1
4461.09	Mn I -28	B1	4479.97	P Fe I -974	B2
4461.21	Fe I -471	B1	4480.14	Fe I -518	H1,B1
4461.22	Zr II-67	H1,B1	4480.69	Fe II-uncl.	H1
4461.65	Fe I -2	H1,B1	4481.13	Mg II-4	H1,B1
4462.02	Mn I -28	H1,B1	4481.33	Mg II-4	H1,B1
4461.99	Fe I -825	H1,B1	4482.17	Fe I -2	H1,B1
4462.28		H2	4482.75	Fe I -828	H1,B1
4462.77	Cr I -127	H1,B1	4483.33	Gd II-62	H1,B1
4463.41	Ce II-20	H1,B1	4483.90	Ce II-3	H1,B1
4463.88		H2	4484.23	Fe I -828	H1,B1
4464.14		H2	4484.68	Cr I -151	H3
4464.46	Ti II-40	H1,B1	4485.01	Ti I -184	B3
4464.91	Cr I -127	B1	4485.15	Eu II-26	H1,B3
4465.36	Cr I -127	H1,B1	4485.54		H3,B3
4465.78	Cr II-191	H1,B1	4486.35	Gd II-135	H1,B1
4466.17	Cr I -127	B1	4486.91	Ce II-57	H1,B1
4466.18	Fe I -901	B1	4487.54		H2,B2
4466.55	Fe I -350	H1,B1	4488.32	Ti II-115	H1,B1
4467.05			4488.82		H3,B3
4467.34	Sm II-53	H1,B1	4489.19	Fe II-37	H1,B1
4467.56	Cr I -127	H1,B1	4489.47	Cr I-uncl.	H1,B1
4468.49	Ti II-31	H1,B1	4489.74	Fe I -2	B1
4469.16	Ti II-18	H1,B1	4490.08	Mn I -22	H1,B1
4469.49		B2	4490.08	Fe I -469	H1,B1
4469.85	Ce II-230		4490.77	Fe I -974	H1,B1
4470.14	Mn I -22	B1	4491.40	Fe II-37	H1,B1
4470.48	Ni I -86	H1,B1	4491.68	Cr I -95	B2
4470.86	Ti II-40	H1,B2	4492.31	Cr I -197	H1,B1
4471.24	Ce II-8	H1,B1	4492.69	Fe I -969	H1,B1
4471.68	P Fe I -2	H3	4492.91		
4472.09	Ca II-6	H1,B1	4493.53	Ti II-18	H1,B2
4472.79	Mn I -22	H1,B1	4493.94		
4472.72	Fe I -595	B1	4494.18		

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4494.57	Fe I -68	H1,B1	4517.10	Gd II-135	H1,B2
4495.39	Fe I -319,970	H3,B3	4517.53	Fe I -472	H1,B1
4496.25	Ti I -8	H3,B2	4518.38	V II-212	H2,B2
4496.86	Cr I -10	H1,B1	4519.02		
4497.25			4519.63	Sm II-49	H1,B1
4497.48			4520.23	Fe II-37	H1,B1
4497.85	Ce II-19	H1,B2	4521.14	Cr I -277	H1,B1
4498.28	Gd II-31	H1,B1	4522.00	Cr I -173	H3,B3
4498.73	Cr I -81	H1,B1	4522.63	Fe II-38	H1,B1
4498.76	La II-94	H1	4523.04	Sm II-3	H1,B1
4499.10		H2,B2	4523.08	Ce II-2	H1,B1
4499.67		H3	4523.47		H2,B3
4500.30	Cr I -150	H3,B1	4523.91	Sm II-41	H1,B1
4500.74		H3	4524.49		B2
4501.27	Ti II-31	H1,B1	4524.64		H3,B2
4501.79	Cr I -81	H1,B1	4524.93	Ba II-3	H1,B1
4502.22	Mn I -22	H1,B1	4525.14	Fe I -826	H1,B1
4502.59	Fe I -796	H1,B1	4525.58		B2
4503.05	Cr I -310	H1	4526.11	Cr I -196	H1,B1
4503.56		H2	4526.47	Cr I -33	H1,B1
4504.52	P Cr II-16		4526.94	Ca I -36	H1,B1
4505.49		H2	4527.34	Cr I -33	H3,B1
4505.85		H2,B2	4527.92		H3
4506.33	Gd II-44	H1,B1	4528.62	Fe I -68	H1,B1
4506.85	Cr I -288	H3,B1	4529.56	P Fe II-171	H1,B3
4506.93	Gd II-13	H1	4529.85	Cr I -33	H1,B1
4507.11	Zr I -31	H3,B2	4530.69	Cr I -33	H1
4507.75		H2,B2	4530.76	Cr I -33	H1,B1
4508.28	Fe II-38	H1,B1	4531.15	Fe I -39	H1,B1
4508.71		H3	4531.63	Fe I -555	H1,B1
4509.08	Gd II-84	H1,B3	4532.50		H3
4509.69		H2,B2	4533.05		H3,B2
4510.16	Pr II-20	H1,B2	4533.14	Fe I -641	
4510.38	Gd II-30	H1,B1	4533.97	Ti II-50	H1,B1
4510.91		H2	4534.17	Fe II-37	H1,B1
4511.18	Ti I-uncl.		4534.78	Ti I -42	H1,B1
4511.82		H3,B2	4535.15	Cr I -33	H1,B1
4512.28	Ca I -24	H1,B1	4535.38		
4512.72	V II-212	B1	4535.72	Cr I -33	H1
4512.73	Ti I -42	H1,B1	4536.66	V I -82	H2
4513.44		H2,B2	4536.86		H2
4514.19	Fe I -514	H1,B1	4537.95	Sm II-45	H1,B1
4514.51	Gd II-103	H1,B3	4538.58	P Fe I -972	H2
4515.09	Sm II-uncl.	B2	4538.84	Fe I -969	H3,B2
4515.34	Fe II-37	H1,B1	4539.10	Ti I-uncl.	H2
4515.87		H2,B2	4539.62	Cr II-39	H1,B1
4516.27	P Fe I -819	H1,B2	4539.76	Ce II-108	H1,B1
4516.56	P Cr II-191	H1,B2	4540.50	Cr I -33	H1,B1

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4540.72	Cr I -150	H1,B1	4563.76	Ti II-50	H1,B1
4541.07	Cr I -33	H1,B1	4564.17	Cr I -312	B1
4541.52	Fe II-38	H1,B1	4564.59	V II-56	B1
4542.62	Cr I -275	H1,B1	4564.72	Fe I -823	H1
4542.62	Cr I -149	H3,B1	4565.04		
4542.60	Nd II-uncl.	H1,B1	4565.45	P Ni I -99	H2
4542.90		H2	4565.78	Cr II-39	H1,B1
4543.74	Cr I -100	H1,B1	4566.14		B2
4543.95	Sm II-32	H1,B1	4566.52	Fe I -641	H2,B1
4544.01	Ti II-60	H1,B1	4566.85		H3,B2
4544.62	Cr I -33	H1,B1	4567.12		
4544.96	Ce II-123		4567.38		
4545.14	Ti II-30	H1,B1	4568.01		H2
4545.34	Cr I -33	H1,B1	4568.31	Ti II-60	H1,B1
4545.96	Cr I -10	H1,B1	4568.79	Fe I -554	H2,B1
4546.68	P Fe I -989	H3,B2	4568.79		
4547.85	Fe I -755	H1,B1	4569.64	Cr I -173	H1,B1
4548.76	Ti I -42	H1	4570.08		B3
4549.21	Fe II-186	H1,B1	4571.24	P Cr II-16	H1
4549.47	Fe II-38	H1,B1	4571.68	Cr I -32	H1,B1
4549.62	Ti II-82	H1,B1	4571.97	Ti II-82	H1,B1
4550.28		H2	4572.28	Ce II-1	H1
4550.75		H3,B2	4572.83	P Cr II-16	H1,B2
4551.30	Ce II-229	H1	4572.86	P Fe I -819	B2
4552.25	P Ti II-30	H1,B1	4573.51		
4552.54	Fe I-uncl.	B1	4573.88		
4554.03	Ba II-1	H1,B1	4574.24	Fe I -554	H2
4554.47	Fe I -319	H2,B3	4575.12	Cr I -196	H1,B1
4555.02	Cr II-44	H1,B1	4575.52	Zr I -5	H2
4555.89	Fe II-37	B1	4575.80	Fe I -593	H2,B1
4556.17	Cr I -173	B1	4576.33	Fe II-38	H1,B1
4556.13	Fe I -410	H1,B1	4576.76	Cr I -148	
4557.03		H2	4577.39		
4557.35		H2,B2	4577.69	Sm II-23	H1,B1
4558.11	Fe I -894	H3,B1	4578.56	Ca I -23	H1,B1
4558.66	Cr II-44	H1,B1	4579.52	Fe II-uncl.	H1,B2
4559.18		B2	4580.06	Cr I -10	H1,B1
4559.48			4580.46	Ti II-60	H1,B1
4560.10	Fe I -823	B2	4581.06	Cr I -148	H1,B1
4560.26	Cr I -211		4581.40	Ca I -23	H1,B1
4560.28	Ce II-8	H1	4581.85		
4560.49			4582.01		
4560.60			4582.38	Gd II-82	H1,B2
4560.96	Ce II-2	H1,B2	4582.84	Fe II-37	H1,B1
4561.48		H2	4583.44	Ti II-39	H1,B2
4562.36	Ce II-1	H1,B1	4583.83	Fe II-38	H1,B1
4563.22		H1,B1	4584.10	Cr I -172	B2
4563.43	Ti I -266	B2	4584.52		H3,B3

TABLE IV (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4584.82	Fe I -822	H1, B1	4608.79		H2
4585.32		B2	4609.26	P Ti II-39	H1, B2
4585.87	Ca I -23	H1, B1	4609.89	Cr I -303	H2
4586.14	Cr I -172	H1, B1	4610.28		
4586.72			4610.59	P Fe II-170	H2
4587.13	Fe I -795	H1, B2	4610.93	V I -39	
4588.22	Cr II-44	H1, B1	4611.29	Fe I -826	H1, B1
4588.67		H3	4611.97	Cr I-uncl.	H1, B1
4589.18			4612.38		
4589.89	Cr II-44	H1, B1	4613.21	Fe I -554	H1, B2
4589.96	Ti II-50	H1, B1	4613.95	Zr II-67	B1
4590.77		H2	4614.22	Fe I -638	
4591.07		H2, B2	4614.52	Cr I -245	B1
4591.49		H3, B3	4614.65		H3
4592.09	Cr II-44	H1, B1	4614.92		H2
4592.66	Fe I -39	H1, B1	4615.55		H3, B2
4594.03	Eu I -1		4616.14	Cr I -21	H1, B1
4593.93	Ce II-6	H1, B2	4616.64	Cr II-44	H1, B1
4594.40	Cr I-uncl.	H3, B1	4617.27	Ti I -145	H1, B1
4595.36	Fe I -594	H3, B1	4618.83	Cr II-44	H1, B1
4595.59	Cr I -286	B1	4619.29	Fe I -821	B2
4596.06	Fe I -820	B2	4620.51	Fe II-38	H1, B1
4596.43	Fe I -823	B1	4621.15		H2
4596.98	Gd II-44	H1, B3	4621.89	Cr I -32	B1
4597.91	Gd II-44	H1, B1	4621.96	Cr I -244	H1, B1
4598.12	Fe I -554	H1, B1	4622.49	Cr I -233	H1, B1
4598.53	Fe II-219	H1, B3	4622.76	Cr I -81	B1
4599.09		H2	4623.02	Co I -156	B1
4600.10	Cr I -32	H1, B1	4623.10	Ti I -145	H1, B1
4600.33		B2	4623.53		H2
4600.75	Cr I -21	H1, B1	4624.29		H3
4601.05	Gd II-44	H1, B1	4625.05	Fe I -554	H1, B1
4601.34	P Fe II-43	H1, B2	4625.55	Fe II-219	H1
4601.97	Zr II-138	H1, B2	4625.96		B3
4602.94	Fe I -39	H1, B1	4626.19	Cr I -21	H1, B1
4603.41		H2	4627.43		B2
4604.25		B2	4627.66	Gd II-43	H1
4604.58	Cr I -190	B2	4628.16	Ce II-1	H1, B3
4604.99	Ni I -98	H1, B1	4628.75	Pr II-1	H3, B1
4605.51		H3, B2	4629.34	Fe II-37	H1, B1
4605.99	P Fe I -893		4630.13	Fe I -115	B1
4606.07			4630.29		
4606.38	Cr I -303	H3, B1	4630.79	Fe I -969	H2
4606.40	Ce II-6	H1, B1	4631.90	Fe II-219	H1
4607.08	P Fe I -724		4632.18	Cr I -171	B1
4607.33	Sr I -2	H1, B1	4632.92	Fe I -39	H1, B2
4607.66	Fe I -554	H1, B1	4633.29	Cr I -186	H1
4608.03	Gd II-144	H1, B2	4633.63		H3

TABLE IV (Concluded)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4634.11	Cr II-44	H1, B1			
4534.76		H3			
4535.33	Fe II-186	H1, B1			
4635.85	Fe I -349	H1, B1			
4636.35	Ti II-38	H1			

TABLE V
LINE IDENTIFICATIONS FOR $\lambda\lambda 4642-4863$

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4642.01	Cr I -244	B1	4669.34	Cr I -186	B1
4642.94		B2	4670.17	Fe II-25	B1
4643.47	Fe I -820	B2	4670.40	Sc II-24	B1
4644.24			4670.94		
4645.19	Ti I -145		4671.36	P Cr II-178	B1
4645.54			4672.30		B2
4645.89			4673.17	Fe I -820	B1
4646.17	Cr I -21	B1	4674.03		
4646.50	Cr I -147		4674.41	Zr II-139	
4647.44	Fe I -409	B1	4675.12	Ti I -77	B1
4647.99			4675.79		
4648.32			4676.41		B2
4648.87	Cr I -32	B1	4676.91	Sm II-3	B1
4649.46	Cr I -32	B1	4677.44		
4649.83	Fe I -592		4678.16	Cd I -2	B1
4650.41			4678.85	Fe I -821	B1
4651.29	Cr I -21	B1	4680.13	Ce II-18	
4652.16	Cr I -21	B1	4680.49	Cr I -186	B1
4652.92			4680.87	Cr I -170	B1
4654.29	Ce II-154	B1	4681.32		
4654.63	Fe I -554	B1	4681.52	A II-76	B2
4654.87			4681.91	Ti I -6	B1
4655.75	P Ti II-38		4683.09		
4656.05	Ti I -145		4683.43	Zr I -63	
4656.19	Cr I -147	B1	4684.25		
4656.47	Ti I -6	B1	4684.77	Cr II-178	B1
4656.97	Fe II-43		4685.27	Ca I -51	B1
4657.79			4686.22	Ni I -98	B2
4658.29	Fe I -591		4686.75		
4658.72			4687.30	P Fe I -17	
4659.08			4688.22		B2
4659.38			4688.45	P V II-45	
4659.93			4688.65	La II-92	
4660.45			4689.37	Cr I -186	B1
4660.93	Fe II-146	B1	4690.15	Fe I -820	B1
4661.54	Fe I -1207	B1	4691.41	Fe I -409	B1
4661.98	Fe I -409		4692.03		
4663.18	Fe I -754		4692.50	La II-75	
4663.76	La II-82	B2	4693.44		
4664.80	Cr I -186	B1	4693.95	Cr I -99	B1
4665.24	P Fe I -1115		4694.31		
4665.90	Cr I -233	B1	4694.84		B2
4666.22	Cr I -99	B1	4695.15	Cr I -99	B1
4666.75	Fe II-37	B1	4697.06	Cr I -62	B1
4667.46	Fe I -822	B1	4697.62	Cr II-177	B1
4668.14	Fe I -554	B1	4698.62	Cr I -62	B1

TABLE V (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4699.32		B2	4723.69		B2
4699.59	Cr I -292	B1	4724.42	Cr I -145	B1
4700.17	Fe I -935	B1	4725.09	Cr II-153	B1
4700.61	Cr I -62	B1	4725.80		
4701.05	Fe I -820	B1	4726.04		B2
4701.54	Ni I -235	B2	4726.73	Gd II-148	B1
4702.02			4727.15	Cr I -99	B1
4702.32	A I -9	B2	4727.41	Fe I -821	B1
4702.98	Mg I -11	B1	4727.48	Mn I -21	B1
4703.62	Hf II-72		4728.47	Gd II-65	B1
4704.00			4729.03	Fe I -1043a	B1
4704.39	Co I -178	B1	4729.29	Ni I -235	
4704.40	Sn II-1	B1	4729.70	Fe I -688	B1
4704.96	Fe I -821	B1	4729.72	Cr I -169	B1
4705.46	Fe I -752	B1	4730.03	Mg I -10	B1
4705.84			4730.71	Cr I -145	B1
4706.10	Cr I -170	B1	4731.03		B2
4706.54	Nd II-3	B1	4731.44	Fe II-43	B1
4707.28	Fe I -554	B1	4732.47	Ni I -235	
4708.04	Cr I -186	B1	4733.60	Fe I -38	B1
4708.66	Ti II-49	B1	4733.95		
4709.09	Fe I -821	B1	4734.09	Sc I -14	B3
4709.72	Mn I -21	B1	4734.10	Fe I -1133	B1
4710.29	Fe I -409	B1	4734.43	Gd II-43	
4710.77			4735.49		B2
4711.25		B2	4735.85	Fe I -1042	B1
4711.91	Zr I -64		4736.78	Fe I -554	B1
4712.39			4737.35	Cr I -145	B1
4712.76		B2	4738.29	Mn II-5	B1
4713.18	P Fe II-26	B1	4739.11	Mn I -21	B1
4714.00	Ce II-250	B1	4739.49	Ce II-157	B1
4714.18	Fe I -591		4740.34	Fe I -409	B1
4714.42	Ni I -98	B1	4741.02	Sc I -14	B2
4714.83	Ce II-17	B1	4741.53	Fe I -346	B1
4715.12	Cr II-178	B1	4742.13	Ti I -202	B1
4716.00			4743.08	La II-75	B1
4716.64	V I -51		4743.11	Cr I -240	B1
4717.69	Cr I -170	B2	4743.71		
4718.43	Cr I -186	B1	4744.37		B2
4719.10	Hf II-15		4744.93	Pr II-3	
4719.52	Ti II-59	B1	4745.31	Cr I -61	B1
4719.93	La II-81		4745.81	Fe I -821	B1
4720.15	P Fe II-54		4746.31		
4721.00	Fe I -409	B1	4746.64	V I -113	
4721.62	A II-85		4747.14	Ce II-uncl.	
4722.28	Sr I -5	B1	4747.00	Cr I -168	
4722.74	Cr I -195	B1	4748.12	P Sc II-48	B1
4723.37	P Ni I -162	B2	4748.66		

TABLE V (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4749.25	P Fe I -1098	B2	4775.53	Cr I -283	
4749.25	Cr I -195	B2	4775.87	P Fe I -1115	
4749.34			4775.87	C I -6	B1
4749.68	Co I -156	B1	4776.20		
4750.61			4776.31	Co I -158	B1
4751.04	Cr I -290	B2	4776.34	Fe I -1206	B1
4751.57	V I -94	B2	4776.80		
4752.08	Cr I-uncl.	B1	4777.13		
4753.15	Sc I -5		4777.57	Cr I -124	
4753.65			4778.12		
4754.04	Mn I -16	B1	4778.50	Cr I -124	
4754.74	Cr I -168	B1	4778.98		
4755.62			4779.35	Sc I -5	
4756.11	Cr I -145	B1	4779.99	Ti II-92	B1
4756.52	Ni I -98	B1	4780.81	P Fe I -633	
4757.37	V I -113	B3	4781.04	Y I -13	
4757.50	V I -113		4781.54		
4757.84	Ce II-uncl.	B1	4781.95	Ne II-71	
4758.74	V I -51		4783.06	Cr I -283	B1
4759.27	Ti I -233		4783.31	Ti I -41	
4760.04		B3	4783.96		B2
4760.59	Hf II-85		4784.32	Sr I -5	B1
4760.79			4784.94	Zr I -44	
4761.53	Mn I -21	B1	4785.34		
4762.38	Mn I -21	B1	4785.78		
4762.77	Ti II-17	B1	4786.81	Fe I -467	B1
4763.87	Nd II-6	B2	4787.12		
4764.64	Cr I -124		4787.64	P Ti I -40	
4764.77	P Mn II-5	B1	4788.19		
4765.23			4788.76	Fe I -588	B1
4765.68			4789.35	Cr I -31	B1
4765.63			4789.65	Fe I -753	B1
4766.03			4790.34	Cr I -31	B1
4766.66	P Cr I -124	B3	4791.15	Gd II-65	B1
4767.28	Cr I -231	B1	4791.25	Fe I -633	B1
4767.86	Cr I -231	B1	4791.00	Ni I -71	
4768.40	Fe I -384		4791.50	Sc I -5	
4768.77		B3	4791.85		
4769.27			4792.51	Cr I -168	B1
4769.45			4793.11		
4769.80	Cr I -283		4793.47	Ni I -158	
4770.33			4793.96	P Fe I -512	
4771.57	Cr I -124		4794.26		B2
4772.82	Fe I -38	B1	4794.84	P Ti II-24	
4773.41	Ni I -167		4795.12		
4773.94	Ce II-17	B1	4795.51		
4774.79			4796.17	Cr I -283	B1
4775.14	Cr I -230	B1	4796.93	V I -113	B1

TABLE V (Continued)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4797.39			4824.13	Cr II-30	B1
4798.54	Ti II-17	B1	4824.76		
4799.06	P Fe I -1098		4824.97	P Cr II-25	
4799.41	Fe I -888	B1	4825.45	Ti I -250	B3
4799.86	Gd II-126	B1	4825.71	P Fe II-30	B1
4800.65	Fe I -1042	B1	4826.32		
4801.03	Cr I -168	B1	4826.65	Pr II-20	
4801.05	Gd II-65	B1	4826.90	Mn I -43	
4801.77			4827.60	Ti I -250	B2
4802.58	Gd II-43		4828.46		
4802.88	Fe I -888	B1	4828.66	Cr I -31	
4803.54	Gd II-102	B1	4829.38	Cr I -31	B1
4804.04	La II-37	B1	4830.06		
4804.64	Cr I -61	B1	4831.11	P Fe II-54	B3
4805.11	Ti II-92	B1	4832.73	Fe I -888	B1
4805.82	Gd II-60		4833.03	V I -78	
4806.26	Cr I -61	B1	4833.21	P Fe II-30	B1
4807.00	Ni I -163		4834.23	Gd II-65	
4807.73	Fe I -688	B1	4835.25		
4808.63		B2	4835.68	Cr I -229	
4809.14	Fe I -933		4836.86	Cr I -144	B1
4809.94	Fe I -793	B1	4837.50		
4810.73	Cr I -144	B1	4838.24	Mn I -43	
4810.76	Fe II-169	B1	4838.52	Fe I -687	B1
4811.88	Sr I -5	B1	4838.81	P Fe I -1167	
4812.35	Cr II-30	B1	4839.08	V II-223	
4813.11	Fe I -630		4839.55	Fe I -588	B1
4813.48	Co I -158	B1	4840.22	Cr I -266	B3
4813.83			4840.89	P Fe I -1070	
4814.27	Cr I -144	B1	4841.27		
4815.33			4841.80	Fe I -1070	
4815.62	Zr I -43		4842.78	Fe I -1069	B1
4816.01	Sm II-41		4843.16	Fe I -687	B1
4816.16			4743.83		
4816.67	P Fe I -588		4844.02	Fe I -750	B1
4817.33	C I -5		4844.21	Sm II-26	B1
4817.77	Fe I -67		4844.65		
4818.26	P Fe II-11	B1	4845.17	Ni I -115	
4819.00		B2	4845.66	Fe I -588	B1
4819.33			4846.47	P Fe II-25	
4820.34	Nd II-47	B1	4846.57	Ce II-17	
4820.81			4846.94		
4821.01	P Ti II-29		4847.30	Ca I -50	B1
4821.41			4847.61	P Fe II-30	
4821.61			4848.24	Cr II-30	B1
4822.06	Cr I -144		4849.18	P Ti II-29	B3
4822.90			4849.67	P Fe I -743	
4823.52	Mn I -16	B1	4849.95		

TABLE V (Concluded)

λ_{RMT}	Ident.	Code	λ_{RMT}	Ident.	Code
4850.23					
4850.58	La II-51,88				
4850.84	Ba II-15				
4850.96					
4851.10	Mg II-25				
4851.36	Zr I -43				
4851.82					
4852.32					
4853.11					
4853.74	Ni I -99				
4853.95					
4854.37	Sm II-36				
4854.60	Mn I -43				
4854.87	Y II-22	B1			
4856.19	Cr II-30	B1			
4856.74					
4857.38	Ni I -111	B3			
4857.60	Cr II-200				
4857.94	Co I -15				
4858.12					
4859.18	La II-86	B3			
4859.58					
4859.75	Fe I -318	B1			
4860.76					
4861.33	H β	B1			
4861.68					
4862.31					
4862.54	P Fe I -1070				
4862.85					

CHAPTER IV

SUMMARY

Line identifications for β Coronae Borealis given in this thesis have significantly extended the spectral region observed by W. A. Hiltner in 1945. In the spectral region common to both there was excellent correlation as expected. Table VI below gives a comparison of the number of lines recorded by Hiltner to those recorded in this work for a particular element in a particular state of ionization over the common spectral region $\lambda\lambda 3980-4638$. The neutral elements and ions identified in the earlier work of Hiltner were all confirmed. Further, for the first time, a number of additional neutral elements and ions were identified.

TABLE VI
COMPARISON OF LINES IDENTIFIED BY HILTNER AND GRUBER

Element	No. of Lines-Hiltner	No. of Lines-Gruber
Fe I	298	307
Fe II	86	77
Cr I	126	163
Cr II	95	58
Ti I	29	30
Ti II	69	67
Ca I	20	21
Ca II	3	2
Co I	3	11
Co II	1	---
Mg I	3	4
Mg II	3	4
Mn I	17	32
Mn II	8	11
Ni I	5	8
Ni II	2	1
Sr I	1	1
Sr II	3	4

TABLE VI (Continued)

Element	No. of Lines-Hiltner	No. of Lines-Gruber
Sc I	2	1
Sc II	11	8
V I	---	11
V II	8	18
Y I	---	2
Y II	3	5
Zr I	---	3
Zr II	16	16
Si II	2	1
Ba II	1	3
Ce II	154	83
Pr II	12	6
Nd II	17	16
Pm II	---	---
Sm II	28	19
Eu I	---	1
Eu II	50	5
Gd II	112	60
La II	13	9
Tm I	---	1
Tm II	1	2
Hf II	---	2
C I	---	1
Mo I	---	1
Mo II	1	---
Gd I	---	1
Tb II	1	---
Unidentified Lines	204	237
Total No. of Lines Re- corded	1364	1309

Table VII below gives a list of all the neutral elements and ions identified over the spectral range considered in this work. The new elements and ions identified in this work are listed at the bottom of Table VII. If only one line was identified, the element or ion was not listed as a new one.

The first column in Table VII identifies the element and its state

TABLE VII
SUMMARY OF ELEMENTS PRESENT IN SPECTRUM OF BETA
CORONAE BOREALIS FOR REGION $\lambda\lambda 3613-4863$

Element	Strength	No. of Lines
Ba II	s	4
Ca I	s	26
Ca II	vs	6
Cr I	vs	276
Cr II	vs	98
Co I	w	31
Co II	*	*
Fe I	vs	590
Fe II	vs	104
Mg I	s	10
Mg II	vs	6
Mn I	ms	54
Mn II	w	13
Ni I	w	33
Ni II	w	2
Si I	--	*
Si II	w	4
Sr I	w	4
Sr II	vs	4
Sc I	w	6
Sc II	ms	18
Ti I	w	56
Ti II	s	101
V II	w	34
Y II	w	17
Zr II	w	33
Mo I	--	3
Mo II	*	---
<u>Rare Earth Elements</u>	<u>Strength</u>	<u>No. of Lines</u>
La II	w	19
Ce II	ms	126
Pr II	w	10
Nd II	w	26
Il II	--	---
Sm II	w	33
Eu I	**	*
Eu II	vs	13
Gd I	--	*
Gd II	ms	101
Tb II	*	---
Dy II	w	***
Ho II	--	---
Er II	--	---

TABLE VII (Continued)

Rare Earth Elements	Strength	No. of Lines
Tm II	*	3
Yb II	--	---
Lu II	--	---
<u>New Elements</u>		
V I		36
Hf II		10
Zr I		9
Mo I		3
Y I		3
C I		3
A II		<u>2</u>
	Total No. of Lines Identified	1926
	Total No. of Lines Recorded	2377

* This indicates only 1 line

** Hiltner indicates he was unable to detect the two strongest lines of the Eu I spectrum. But on the tracings used for this thesis the strongest line was identified.

*** Since the Finding List did not give the λ (RMT) for Dy II these lines were not identified.

of ionization. The second column indicates whether Hiltner showed the identifications as being: very strong (vs), strong (s), moderately strong (ms) or weak (w) over his shortened spectral range. The third column indicates the number of lines identified in the tracings from plate D-2829a.

When Hiltner refers to identifications that are strong he is referring to the intensities of the lines present. Very strong corresponds to the highest intensity while weak refers to the lowest intensity. The work in this thesis was entirely based on the measurements of wavelengths. No intensities were assigned and yet the number of lines is

one kind of indication of strength.

In conclusion this is a necessary and significant step in the direction of making abundance determinations for the star β Coronae Borealis and it is the first step for the group at Oklahoma State University.

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