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PART II

SOLAR ROTATION—SECTIONS 1-3

BY

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SOLAR ROTATION

SECTION I—INTRODUCTION AND OBSERVATIONS OF THE EQUATORIAL VELOCITY IN 1909

BY
RALPH E. DE LURY

Introduction.—The investigation of the velocity of the solar rotation by measurement of the displacements it produces in the lines of spectra from points on the advancing and receding sides of the sun was commenced at Ottawa in 1909, at a time when extensive and continuous observations were greatly desired for the further elucidation of several important questions which had been raised by the previous attacks on the problem.

Not many years earlier, in 1871, Vogel and Zöllner succeeded in detecting the Fizeau displacement of the spectrum lines due to the rotational velocity of the solar limb, thus adding to the results of the work of Huggins, in 1868, on the displacements of stellar spectrum lines convincing evidence of the validity of the principle enunciated by Doppler in 1842. However, it was obvious that the spectroscopic determination of the solar rotation could be successfully accomplished only by use of spectra of very large scale. In 1876 Young demonstrated the power and convenience of the diffraction grating in measuring the solar rotational displacements of the spectrum lines.

Employing plane grating spectrosopes, series of visual observations of the displacements of two solar lines near $\lambda 6300$, with reference to undisplaced lines originating in the terrestrial atmosphere, in spectra from opposite points on the solar limb, were made by Dunér at Lund (1887–9), and again by Dunér and Bergstrand at Upsala (1898–1901) and by Halm at Edinburgh (1901–6), while photographic observations of the $\lambda 4250$ region of the spectrum and of H_α were obtained by Adams at Mount Wilson (1906–8).

Dunér's pioneer investigations confirmed, for the general surface of the sun, Carrington's discovery from observations of sunspots (1853–61) of the gradual lessening of the angular rate of rotation with departure in latitude from the equator, and also extended the knowledge of the rate to the higher latitudes beyond the range in which sunspots occur. Halm called attention to the variation in the measurements of the velocity of rotation and suggested that this might be related to the cyclical fluctuation in sunspots. Adams found differences in the measurements of the rotation displacements of spectrum lines of different elements which he ascribed to differences in level in the solar atmosphere of the materials producing the spectrum lines. All of the determinations, though exhibiting considerable individuality in numerical details, pointed to the Faye formula, $A - B \sin^2\phi$ as a close approximation to the angular velocity of rotation in terms of the latitude, ϕ .

In these measurements progressive improvement resulted from increasing the focal length and stability of the spectrosopes and the diameter of the solar image. Consequently, the focal length of the Ottawa auto-collimating plane grating spectrograph¹ was chosen as large as the laboratory space permitted, namely 7 m. (23 ft.), to be used with a solar image of average diameter of about 228 mm. (9 in.) supplied by a 51 cm. (20 in.) coelostat² and a similar second flat mirror to feed the sun's light to a 46 cm. (18 in.) con-

^{1, 2} Rept. Chief Astronomer, 1909, 251–4, and 207–9.

cave mirror of 24·4 m. (80 ft.) focal length. A detailed description of this equipment, with later improvements and additions, is given in the previous Part I of this Volume, pp. 11-17, and an outline of observations made with it, pp. 5-7.

The coelostat and spectrograph were mounted in 1908, and tests and observations revealed the worthless character of the plane grating, which was not only decidedly lacking in brightness in all orders of spectra but was incapable of yielding sharp spectrum lines. After some construction work within the building the spectrograph was remounted in 1909, and focal tests in the various orders of the grating indicated a curvature of its rulings of about half their spacing³. Nevertheless, using about 8 cm. of the length of the rulings a few photographic observations were made, recording spectra of opposite points near the limb at the solar equator and a few other latitudes. Finally, in 1910, with a new plane grating, satisfactory observations at $\lambda 4500$ were made during the summer, recording solar rotation spectra at various latitudes. Later in the year the International Union for Co-operation in Solar Research initiated a program⁴ for investigating the solar rotation, in which seven regions of the spectrum were assigned to six co-operating observatories. By this arrangement the Dominion Observatory was to observe the spectrum from $\lambda 5500$ to $\lambda 5700$ as well as a common region about $\lambda 4250$. In consequence, rotation plates at $\lambda 5600$ were secured in November and December of that year, and with another more satisfactory grating observations at that region have been made yearly since then, along with series at $\lambda 4250$ and at certain other wave-lengths in some years.

Before presenting the measurements of the various series of solar rotation plates, a brief outline will be given of several supplementary investigations and suggestions made by the writer in the earlier years, as these are used in the discussion and interpretation of the measurements of the solar rotations.

Errors of Micrometer Measurement.—Systematic errors were found in the earliest measurements of the solar rotation plates. These were investigated by measuring plates on which the spectrum lines were mechanically shifted⁵ either by moving the plate-holder between exposures on adjacent strips of spectrum or by using a slit with an offset section by means of which displacements imitating the actual rotation displacements, the same for all lines, were recorded. The measurements of these artificial displacements revealed:—

- (1) Measurements made with the plate "violet left" and "violet right" differed systematically;
- (2) Systematic differences were found depending on the character of the spectrum lines;
- (3) Various observers obtained systematically different values;
- (4) The errors were large enough to make uncertain the conclusions concerning the interesting fine points in the investigation of the solar rotation.

As a result of this work and the variety of results obtained by different observers of the solar rotation, the International Union for Co-operation in Solar Research at its last meeting in 1913 suggested⁶ that in further co-operative work special attention should

³ Rept. Chief Astronomer, 1911, 256-259.

⁴ Trans. Int. Union Solar Res., Vol. III, p. 83.

⁵ Jour. Roy. Astron. Soc. Can., V, 384-407, 1911; also, Rept. Chief Astronomer, 1911, 264-281.

⁶ Trans. Int. Union Solar Res., IV, 123.

be paid to the investigation of such errors, especially in measurements of the equatorial velocity of the solar rotation.

Finally, the cause of these errors was traced to capillary action of the oil between the nut and micrometer screw⁷, which moved the nut, and with it the plate-frame holding the plate, in one direction for about three minutes, during which the measurements of the rotation displacements were usually made. It was possible to remove or control the error in later measurements and to determine its extent in the earlier measurements by repeating some of them.

Blended Spectra.—The measured values of the solar rotation displacements are reduced by the overlapping undisplaced spectrum lines from the light of the sky and its haze, and conceivably a similar blending effect might be caused by the optical parts of the observational equipment or by meteoric matter falling into the sun across the line of sight at or near the solar limb. Halm called attention to the lessening effect of a hazy sky and took precautions to avoid this as much as possible in his observations. It may be remarked that his ingenious device of using a heliometer to juxtapose two solar images on the slit of the spectroscope introduced a double effect of sky spectrum. The question was investigated by measuring artificial blends of varying amounts of centre and limb spectra⁸. A striking though expected result of these measurements was the finding of a differential effect depending on the character of the spectrum lines. In general for weak lines a greater lessening of the measured displacements was observed than for strong lines attributed to the relative differences in intensity, and possibly also in wave-length, of the lines in the two sources. The greater the decrease in the mean value of the displacement, the greater was found to be the difference between the values for weak and for strong lines. A similar effect is found in the actual observations of the solar rotation^{9, 10}; and a large series of observations would thus contain the means for determining the value of the rotation for a zero difference between the values of weak and strong lines. Observations of limb spectra when the sun is nearly totally eclipsed would be free of the effect of sky spectrum¹¹. The selective reflection of cirrus ice crystals and water droplets might result in a greater effect on spectrum lines in the green and yellow.

Reference Spectra.—In order to determine independently the velocity of rotation at each observed point, or to interpret abnormal results, it was proposed to photograph, simultaneously with the limb spectra, the spectrum of the centre of the solar disc, gaseous absorption spectra and spectra of the metallic elements¹². Such reference and comparison spectra have been employed since 1913, and they serve as well in the determinations of wave-length and of the solar distance.

Pore Theory.—To account for the redward shift and widening of most of the limb spectrum lines and for differences occurring between the measurements of observations of the solar rotation made in rapid succession which appear too great to be explained as due to error of observation or of measurement, a theory was advanced¹³ that the darker

⁷ Pub. Dom. Obs. VI, Pt. I, 18–23.

⁸ J. Roy. Astron. Soc. Can., X, 201–219, 1916; also, Pub. Dom. Obs. VI, Pt. I, 41–45.

⁹ Astrophys. J. 44, 177–189, 1916.

¹⁰ J. Roy. Astr. Soc. Can. 10, 345–357, 1916.

¹¹ Astrophys. J. 47, 199, 1918.

¹² Rept. Chief Astronomer, 1910, 168; 1911, 290 and 293.

¹³ Pub. Am. Astron. Soc. IV, 149.

"pores", lying among the brighter "granules" and constituting with them the general surface of the sun, have a similar convective system to that in the penumbra of a sunspot. This theory is supported by measurements of the penumbral displacements in sunspots situated at varying distances within the solar limb¹⁴.

Computation.—In computing the velocity of the solar rotation from the measured displacement of a line in the spectrum of a limb point, Dunér employed an approximate method of correcting for the orbital velocity of the earth, adding the correction to the product of the velocity-equivalent of the displacement and the secant of the angle, η , between the direction of rotation at the limb point and the direction of the radius vector to the earth. Obviously, the correction should be added to the velocity-equivalent of the displacement before multiplying by the factor $\sec \eta$. The values of the rotational velocity determined by Dunér's method are too small by the quantity, $v_1 (\sec \eta - 1)$, where v_1 , in Dunér's notation, is the difference between the components of the earth's orbital velocity to the centre and to the limb point of the solar disc. At times this error is large enough to affect seriously the determinations of the rotational velocities at the higher latitudes. To apply properly the correction due to the orbital velocity of the earth and at the same time to provide a method applicable not only to limb observations but to any pairs of points on the sun, usually selected for obvious reasons equidistant from the centre of the solar disc, the writer suggested the following system which was used in our first determinations of the law of the solar rotation¹⁵:

d mm. is the measured difference of position or displacement of a spectrum line in the spectra from the two points which are at latitudes ϕ_1 and ϕ_2 ;

F km. per sec. is the velocity-equivalent of a displacement of 1 mm. of the spectrum line;

γ_1 and γ_2 are the angles between the directions of rotation and the lines to the observer at the two points;

V_1 and V_2 the rotational velocities at the two observed points;

ϵ km. per sec. is the difference between the components of the earth's orbital velocity to the two points; hence,

$$d.F + \epsilon = V_1 \cos \gamma_1 + V_2 \cos \gamma_2.$$

Without further information, this equation can be solved only when,

- (1) the points are on the equatorial diameter of the solar disc, or on a line parallel to it, and $d.F + \epsilon = 2V \cos \gamma$;
- (2) one point is on the polar diameter of the solar disc, in which case $d.F + \epsilon = V \cos \gamma$;
- (3) the points are on a diameter of the solar disc, and the observer is on the plane of the solar equator, in which case $d.F + \epsilon = (V_1 + V_2) \cos \gamma$, and the average velocity in the north and south hemispheres is determined for the latitude observed.

The additional data provided by the use of a reference spectrum, such as mentioned above, permit the independent determination of V_1 and V_2 ; or an approximate solution

¹⁴ Pub. Am. Astron. Soc. IV, 214, 215 and 258.

¹⁵ Trans. Roy. Soc. Can., Vol. VI, Sec. III, 1-48, 1912.

is provided by a determination of the law of rotation, from which the ratio $V_1 : V_2$ may be derived for the latitudes ϕ_1 and ϕ_2 . This latter method was used, perforce, in the 1911 observations¹⁵.

Observations of the Equatorial Velocity of Rotation in 1909.—The few observations of the solar rotation made in 1909, while of poor quality because of the grating employed, have a special value in view of the scarcity of observations in that year and also because the measurements of the equatorial velocity made previously were about 5 per cent greater on the average than those made in subsequent years. Consequently, it was considered advisable to remeasure the 1909 plates, since the earlier measurements of them were probably affected by the systematic error later traced to the action of the micrometer oil.

In making the observations, the grating, which had a surface 10·8 by 12 cm. with 500 rulings to 1 mm., was masked to an area 8 by 8 cm. on account of the curvature of the rulings and the poorer quality of one end. Two slots slightly wider than 1·6 mm. (one-sixteenth of an inch) admitted light from within the equatorial limbs of the sun to reflecting prisms which directed one beam from the east limb to the slit of the spectrograph between two beams from the west limb, the prisms being adjusted so that all beams illuminated fully the part of the grating which was not masked. Focusing of the brighter third order spectrum was as accurate as the poor quality of the spectrum lines permitted. Long exposures of from 10 to 15 minutes were necessary, 6·3 cm. by 30·5 cm. (2·5 in. by 12 in.) process plates being used. During the exposures the solar disc was held centrally on a guide-plate by turning the drums which, by means of stretched strings, operated the adjusting handles on the mounting of the concave mirror of the coelostat telescope¹⁶. The silver-plated slotted plates were mounted on the guide-plate so that the middle of the slots could be placed the desired distance within the limb by referring to an engraved millimetre scale on the guide-plate.

In Table I the record of observations is given: plate number; date and hour of observation; position of observed points, including the position angle, α , measured from the equatorial diameter of the solar disc, the diameter of the disc and the distance, r , of the observed points from the centre of the disc expressed as a decimal of its radius; the width of the slit of the spectrograph; the exposure time; and the observing conditions and remarks, D and B representing the definition and brightness of the solar image.

In Table II are given, for each spectrum line selected for measurement: λ , the wave-length in Ångstrom units (the Rowland values and the last three figures of the International system); the element; the intensity; and F , in km. per sec., the velocity-equivalent of a displacement of 1 mm. of the spectrum line, defined by the equation, $F\lambda = (\text{scale}) (\text{velocity of light}) = 0\cdot8927$ (velocity of light), since 1 mm. = 0·8927 Å (for the $\lambda 4250$ plates). Further details of the two groups of lines at $\lambda 4250$ and $\lambda 4500$ will be given in the discussion of later series of observations.

In Table III are given the measurements and derived velocities for the individual spectrum lines in each observation. Each form provides for the results of four measurements, the measuring instrument used for each being indicated in turn, after the initial

¹⁵ J. Roy. Astron. Soc. Can., V, 33–35, 1911; Rept. Chief Astronomer, Vol. I, 1910, 169–170.

of the measurer, by T for the Toepfer 300 mm. measuring machine, and by -C for the Ottawa double spectrocomparator¹⁷, when employed as in this series in measuring negatives singly. For each observation, the following essential observed, measured, and computed quantities are given:

- α , the position angle of an observed point measured from the equatorial diameter of the solar disc;
- r , the distance of the observed points from the centre of the solar disc, the radius of the disc being taken as unity;
- B_o , the latitude of the centre of the solar disc;
- β , the position angle of an observed point measured from the ecliptic diameter of the solar disc;
- ϵ , in km. per sec., the difference between the components of the earth's orbital velocity to the two observed points;
- ϕ , the latitude of each of the observed points;
- γ , the angle between the direction of rotation at an observed point and the line from the point to the observer;
- d , in mm., the mean displacement of a spectrum line in the east with reference to the west spectra, plate measured both ways, "violet left" and "violet right";
- V , the velocity of rotation at each point;
- v , the sum, without regard to direction of rotation, of the components of V along the lines of sight at the two points.

Thus, $v = F \cdot d + \epsilon = 2V \cos \gamma$; or, $0.5v \sec \gamma = V$.

Determinations of β , ϵ , ϕ , and γ are readily made with the use of the tables and mechanical devices described in Sections 7, 8, and 9 of Part I of this volume.

Summary of Results.—The inferior spectroscopic and photographic quality of the plates precludes the possibility of fine measurement. Results obtained in 1909 include: L413, 79 lines, 5 settings on each line in each strip of spectrum, mean value 1.97 km. per sec., with a probable residual of 0.01 km. per sec., and a probable residual of the value from a single line of 0.10 km. per sec. Similar measurements of L393 and L399, 20 lines and 40 lines respectively, yielded mean values of 1.97 km. per sec. and 1.91 km. per sec. Later measurements were: L393, 27 lines, plate "violet left" and "violet right", yielding a mean value of 1.82 km. per sec., 4 settings on each line in the central strip and 2 settings on each line in each of the two outside strips being made; and 7 plates, L412-L419, 15 lines, violet left and violet right, giving a mean value of 2.039 km. per sec. The measurements of this group of 7 plates are given in Table III, accompanied by duplicate measurements, made in a manner to eliminate the micrometer oil error and yielding a mean value of 2.004 km. per sec. The difference between these two sets of measures appears to be systematic and ascribable to the oil error in the earlier series. The measurements of the 4 earlier plates (L315, L317, L393, and L399) given in the table are also practically free of the oil error.

In all, there are 22 measurements of the 11 plates which yield a mean value of 1.967 km. per sec. If the earlier measurements which were liable to have a systematic error due to the oil are discarded, the mean of the 11 measures of the 11 plates is 1.94 km. per sec. for the equatorial velocity of the solar rotation. From later experiences it seems very likely that the abnormally low values of plates L315, L317, L393 and L399 are due to the hazy observing conditions on the days they were made; and if these measurements be discarded the resulting mean of the measurements of the 7 plates, L412-L419, observed under fair conditions, is 2.00 km. per sec.

Thus it would seem that the observations of 1909 yield values of the solar rotation falling within the range of values obtained in subsequent years rather than being in agreement with the large values obtained in the years preceding 1909.

TABLE I—RECORD OF OBSERVATIONS OF THE SOLAR ROTATION, 1909

Plate	1909		Position			Slit Width	Ex- posure	Observing Conditions and Remarks		
	Date	E.S.T.	α	Disc	r			D	B	
L		h. m.	$^{\circ}$	mm.		mm.	sec.			
315	June 21	11 34	0	225.4	0.984	0.025	600			Unsteady. Hazy day.
317	" 23	11 04	0	226.5	0.979	0.025	720			"
393	Sept. 8	9 32	0	228.0	0.991	0.025	600			"
399	" 8	2 30	0	228.0	0.991	0.025	900			"
412	Oct. 5	11 42	0	232.0	0.983	0.028	600	Fair	Fair	
413	" 5	12 15	0	232.0	0.974	0.038	600	"	"	
414	" 5	2 35	0	232.0	0.974	0.038	600	"	"	
417	" 6	10 00	0	233.0	0.970	0.038	600	Poor	"	
418 (1)	" 8	12 15	0	234.0	0.966	0.038	600	"	"	
418 (2)	" 8	12 26	0	234.0	0.966	0.038	600	"	"	
419 (1)	" 8	3 02	0	234.0	0.966	0.038	660	"	"	

TABLE II—THE SPECTRUM LINES MEASURED AND THEIR VELOCITY FACTORS, F, FOR 1 MM. DISPLACEMENT

λ		Element	Intensity	F	λ		Element	Intensity	F
Rowland	I.A.				Disc	Rowland	I.A.		
\AA				km./sec.	\AA				km./sec.
4196.699	.547	Fe-La ⁺	1	63.82	4376.942	.784	Fe-Cr	1	61.08
4197.257s	.102	CN	2	.80	4379.927	.771	Zr ⁺ Cr	0	.02
4216.136s	5.978	Fe-CN	1	.52	4383.720s	.559	Fe	15	60.96
4220.509	.349	Fe	3	.46	4404.927s	.763	Fe	10	.56
4225.619	.463	Fe	3	.38	4415.293s	.137	Fe	8	.36
4232.887	.736	Fe	2	.28	4416.636	.477	V	0	.34
4241.285	.122	Fe	2	.16					
4246.996	.838	Sc ⁺	5	.06					
4257.815	.663	Mn	2	62.90					
4258.477	.326	Fe	2	.90	4554.211s	.038	Ba ⁺	8	58.06
4266.081	5.927	Mn	2	.78	4554.626	.462	Fe	1	.06
4268.915	.758	Fe	2	.74	4561.591	.419		1	57.94
4276.836	.683	Fe	2	.62	4563.939s	.768	Ti ⁺	4	.84
4290.377	.228	Ti ⁺	2	.42	4572.156s	1.982	Ti ⁺	6	.74
4291.630	.475	Fe	2	.40	4574.396	.227	Fe	1	.70

TABLE III—RESULTS FROM INDIVIDUAL OBSERVATIONS OF THE SOLAR ROTATION, 1909

Plate:	L315, June 21, 11:34, E.S.T.			L317, June 23, 11:04			L412, Oct. 5, 11:42					
De L. on T												
" T, -C	$\alpha = 0^\circ \beta = 7^\circ 0 \gamma = 10^\circ 5$			$\alpha = 0^\circ \beta = 6^\circ 9 \gamma = 12^\circ 0$			$\alpha = 0^\circ \beta = 3^\circ 4 \gamma = 12^\circ 3$					
" T	$r = 0.984 \epsilon = 0.262 \phi = 0^\circ 3$			$r = 0.979 \epsilon = 0.260 \phi = 0^\circ 4$			$r = 0.983 \epsilon = 0.271 \phi = 1^\circ 2$					
" -C	$B_o = 1^\circ 9 \quad 0.5085v = V$			$B_o = 2^\circ 1 \quad 0.5111v = V$			$B_o = 6^\circ 4 \quad 0.5118v = V$					
λ	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4196-699	0.0551	1.889	1.921	0.0506	1.745	1.784	0.0570	1.955	2.001	0.0543	1.868	1.912
4197-257	0.0546	1.873	1.905	0.0464	1.610	1.646	0.0645	2.194	2.246	0.0605	2.066	2.115
4216-136	0.0538	1.840	1.871	0.0597	2.026	2.071	0.0604	2.054	2.102	0.0629	2.134	2.184
4220-509	0.0575	1.955	1.988	0.0491	1.688	1.725	0.0493	1.700	1.740	0.0499	1.719	1.760
4225-619	0.0510	1.747	1.777	0.0555	1.889	1.931	0.0600	2.037	2.085	0.0581	1.977	2.024
4232-887	0.0472	1.624	1.651	0.0588	1.990	2.034	0.0594	2.015	2.063	0.0588	1.838	1.881
4241-285	0.0533	1.814	1.845	0.0482	1.652	1.689	0.0564	1.917	1.962	0.0597	2.021	2.069
4246-996	0.0465	1.597	1.624	0.0566	1.915	1.958	0.0554	1.883	1.927	0.0512	1.750	1.791
4257-815	0.0542	1.836	1.867	0.0566	1.910	1.952	0.0618	2.080	2.129	0.0587	1.982	2.029
4258-477	0.0488	1.666	1.694	0.0537	1.819	1.859	0.0546	1.853	1.897	0.0567	1.919	1.964
4266-081	0.0434	1.493	1.518	0.0552	1.863	1.904	0.0554	1.875	1.919	0.0526	1.787	1.829
4268-915	0.0571	1.922	1.954	0.0518	1.755	1.794	0.0612	2.056	2.105	0.0604	2.031	2.079
4276-836	0.0484	1.646	1.674	0.0530	1.789	1.829	0.0554	1.871	1.915	0.0579	1.949	1.995
4290-377	0.0503	1.701	1.730	0.0580	1.940	1.983	0.0604	2.208	2.260	0.0609	2.037	2.085
4291-630	0.0512	1.728	1.757	0.0527	1.774	1.813	0.0607	2.030	2.078	0.0602	2.014	2.062
Means:			1.785			1.865			2.029			1.985
Plate:	L413, Oct. 5, 12:15, E.S.T.						L414, Oct. 5, 2:35 E.S.T.					
De L. on T												
" -C	$\alpha = 0^\circ \beta = 3^\circ 4 \gamma = 14^\circ 5$						$\alpha = 0^\circ \beta = 3^\circ 4 \gamma = 14^\circ 5$					
" T	$r = 0.974 \epsilon = 0.269 \phi = 1^\circ 4$						$r = 0.974 \epsilon = 0.269 \phi = 1^\circ 4$					
" -C	$B_o = 6^\circ 4 \quad 0.5164v = V$						$B_o = 6^\circ 4 \quad 0.5164v = V$					
λ	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4196-699	0.0537	1.846	1.906	0.0560	1.920	1.983	.....	.....	.....	.....	.....	.....
4197-257	0.0534	1.838	1.898	0.0558	1.915	1.978	.....	.....	.....	.....	.....	.....
4216-136	0.0595	2.024	2.090	0.0508	1.746	1.803	0.0546	1.867	1.928	0.0555	1.897	1.959
4220-509	0.0609	2.083	2.151	0.0542	1.854	1.915	0.0542	1.855	1.916	0.0588	2.001	2.066
4225-619	0.0547	1.869	1.930	0.0585	1.987	2.052	0.0588	1.998	2.063	0.0504	1.730	1.787
4232-887	0.0540	1.841	1.901	0.0539	1.838	1.898	0.0611	2.065	2.133	0.0505	1.953	2.017
4241-285	0.0508	1.737	1.794	0.0547	1.862	1.923	0.0651	2.192	2.264	0.0617	2.084	2.152
4246-996	0.0586	1.983	2.048	0.0586	1.982	2.047	0.0586	1.980	2.045	0.0538	1.839	1.899
4257-815	0.0554	1.875	1.936	0.0564	1.908	1.970	0.0665	2.227	2.300	0.0636	2.136	2.206
4258-477	0.0602	2.027	2.093	0.0572	1.931	1.994	0.0603	2.020	2.095	0.0606	2.038	2.105
4266-081	0.0509	1.730	1.787	0.0585	1.972	2.036	0.0601	2.020	2.086	0.0574	1.934	1.997
4268-915	0.0562	1.895	1.957	0.0539	1.825	1.885	0.0613	2.057	2.124	0.0633	2.120	2.189
4276-836	0.0567	1.909	1.971	0.0490	1.668	1.723	0.0588	1.974	2.039	0.0578	1.944	2.008
4290-377	0.0547	1.842	1.902	0.0551	1.852	1.913	0.0637	2.123	2.192	0.0691	2.292	2.367
4291-630	0.0557	1.870	1.931	0.0581	1.949	2.013	0.0616	2.055	2.122	0.0594	1.988	2.053
Means:			1.953			1.942			2.101			2.062

TABLE III—RESULTS FROM INDIVIDUAL OBSERVATIONS OF THE SOLAR ROTATION, 1909—
Continued

Plate:	L417, Oct. 6, 10:00, E.S.T.						L418 (1), Oct. 8, 12:15					
De L. on T												
" —C	$\alpha = 0^\circ \quad \beta = 3^\circ 6 \quad \gamma = 15^\circ 3$ $r = 0.970 \quad e = 0.268 \quad \phi = 1^\circ 6$ $B_o = 6^\circ 3 \quad 0.5184v = V$						$\alpha = 0^\circ \quad \beta = 3^\circ 7 \quad \gamma = 16^\circ 1$ $r = 0.966 \quad e = 0.267 \quad \phi = 1^\circ 7$ $B_o = 6^\circ 3 \quad 0.5205v = V$					
λ	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	k.m./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4196-699	0.0574	1.966	2.038	0.0547	1.879	1.948	0.0616	2.100	2.186	0.0544	1.870	1.946
4197-257	0.0585	2.000	2.074	0.0542	1.863	1.932	0.0644	2.188	2.277	0.0690	2.335	2.431
4216-136	0.0541	1.852	1.920	0.0525	1.801	1.867	0.0489	1.687	1.756	0.0408	1.430	1.488
4220-509	0.0573	1.952	2.024	0.0557	1.901	1.971	0.0516	1.771	1.843	0.0516	1.771	1.843
4225-619	0.0546	1.864	1.933	0.0560	1.909	1.979	0.0508	1.744	1.815	0.0530	1.814	1.888
4232-887	0.0553	1.884	1.953	0.0575	1.953	2.025	0.0641	2.162	2.250	0.0598	2.026	2.109
4241-285	0.0542	1.846	1.914	0.0576	1.953	2.025	0.0550	1.871	1.948	0.0545	1.855	1.931
4246-996	0.0589	1.991	2.064	0.0553	1.878	1.947	0.0678	2.272	2.365	0.0543	1.846	1.922
4257-815	0.0529	1.798	1.864	0.0556	1.883	1.952	0.0506	1.725	1.796	0.0553	1.873	1.950
4258-477	0.0609	2.049	2.124	0.0528	1.795	1.861	0.0555	1.879	1.956	0.0574	1.939	2.018
4266-081	0.0546	1.848	1.916	0.0505	1.719	1.782	0.0602	2.024	2.107	0.0581	1.958	2.038
4268-915	0.0607	2.038	2.113	0.0568	1.916	1.987	0.0548	1.853	1.929	0.0551	1.862	1.938
4276-836	0.0561	1.890	1.960	0.0513	1.740	1.804	0.0563	1.897	1.975	0.0606	2.031	2.114
4290-377	0.0596	1.994	2.067	0.0563	1.891	1.961	0.0617	2.060	2.144	0.0562	1.888	1.965
4291-630	0.0518	1.750	1.814	0.0525	1.772	1.837	0.0519	1.753	1.825	0.0557	1.872	1.949
Means:		1.985			1.925				2.011			1.969
Plate:	L418 (2), Oct. 8, 12:26, E.S.T.						L419 (1), Oct. 8, 3:02, E.S.T.					
De L. on T												
" —C	$\alpha = 0^\circ \quad \beta = 3^\circ 7 \quad \gamma = 16^\circ 1$ $r = 0.966 \quad e = 0.267 \quad \phi = 1^\circ 7$ $B_o = 6^\circ 3 \quad 0.5205v = V$						$\alpha = 0^\circ \quad \beta = 3^\circ 7 \quad \gamma = 16^\circ 1$ $r = 0.966 \quad e = 0.267 \quad \phi = 1^\circ 7$ $B_o = 6^\circ 2 \quad 0.5205v = V$					
λ	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4196-699	0.0562	1.927	2.006	0.0560	1.921	2.000	0.0583	1.994	2.076	0.0535	1.841	1.916
4197-257	0.0635	2.150	2.238	0.0644	2.188	2.277	0.0625	2.128	2.215	0.0479	1.662	1.730
4216-136	0.0625	2.119	2.206	0.0668	2.256	2.348	0.0511	1.757	1.829	0.0593	2.017	2.099
4220-509	0.0598	2.031	2.114	0.0586	1.993	2.075	0.0613	2.079	2.164	0.0707	2.377	2.474
4225-619	0.0601	2.039	2.122	0.0612	2.073	2.158	0.0550	1.877	1.954	0.0620	2.099	2.185
4232-887	0.0603	2.042	2.126	0.0555	1.890	1.967	0.0672	2.260	2.352	0.0608	2.058	2.142
4241-285	0.0535	1.824	1.899	0.0578	1.959	2.039	0.0616	2.079	2.164	0.0652	2.193	2.283
4246-996	0.0626	2.108	2.194	0.0539	1.833	1.908	0.0587	1.985	2.066	0.0625	2.105	2.191
4257-815	0.0588	1.983	2.064	0.0554	1.876	1.953	0.0642	2.153	2.241	0.0586	1.977	2.058
4258-477	0.0543	1.842	1.917	0.0565	1.911	1.989	0.0570	1.927	2.006	0.0549	1.861	1.937
4266-081	0.0621	2.083	2.168	0.0552	1.867	1.943	0.0628	2.105	2.191	0.0622	2.086	2.171
4268-915	0.0574	1.935	2.014	0.0642	2.148	2.236	0.0600	2.016	2.098	0.0535	1.812	1.886
4276-836	0.0597	2.003	2.085	0.0634	2.119	2.206	0.0598	2.006	2.088	0.0548	1.850	1.926
4290-377	0.0623	2.078	2.163	0.0594	1.988	2.069	0.0615	2.053	2.137	0.0563	1.891	1.968
4291-630	0.0546	1.838	1.913	0.0570	1.912	1.990	0.0606	2.025	2.108	0.0591	1.978	2.059
Means:		2.082			2.077				2.113			2.068

TABLE III—RESULTS [FROM INDIVIDUAL OBSERVATIONS OF THE SOLAR ROTATION, 1909—*Concluded.*

Plate:	L393, Sept. 8, 9.37, E.S.T.			L399, Sept. 8, 2.38, E.S.T.		
De L. on — C	$\alpha=0^\circ$	$\beta=0^\circ 0$	$\gamma=10^\circ 6$	$\alpha=0^\circ$	$\beta=0^\circ 0$	$\gamma=10^\circ 6$
" "	$r=0.991$	$\epsilon=0.272$	$\phi=1^\circ 1$	$r=0.991$	$\epsilon=0.272$	$\phi=1^\circ 1$
	$B_0=7.25$	$0.5090v = V$		$B_0=7.25$	$0.5090v = V$	
λ	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0490	1.631	1.660	0.0474	1.582	1.610
4379.927	0.0511	1.697	1.728	0.0610	1.998	2.034
4383.720	0.0530	1.750	1.782	0.0619	2.021	2.057
4404.927	0.0560	1.832	1.865	0.0627	2.036	2.073
4415.293	0.0486	1.602	1.631	0.0554	1.807	1.840
4416.636	.....	.....	.....	.....	.....	.....
4554.211	0.0643	2.002	2.038	0.0528	1.669	1.699
4554.626	0.0621	1.939	1.974	0.0586	1.836	1.869
4561.591	0.0593	1.856	1.889	0.0598	1.868	1.902
4563.939	0.0539	1.696	1.727	0.0524	1.651	1.681
4572.156	0.0537	1.685	1.715	0.0528	1.662	1.692
4574.396	0.0630	1.953	1.988	0.0525	1.651	1.681
Means:			1.817			1.831

SOLAR ROTATION

SECTION 2—DETERMINATIONS OF THE EQUATORIAL VELOCITY FROM OBSERVATIONS AT $\lambda 4500$ IN 1910

BY

RALPH E. DE LURY AND JOHN L. O'CONNOR

The observational equipment employed in 1910 was the same as in 1909 with the exception of the grating. A second Michelson plane grating, No. 55, was received in April and immediately mounted in the spectrograph. Its surface was 11 by 13 cm., ruled 700 lines to 1 mm. Astigmatism was removed from the spectrum by masking 5 cm. off one end of the rulings, and the sharpness of the spectrum lines was improved by occulting 5 cm. from one end of the ruled surface. The remaining area, 6 by 8 cm., was placed with its centre on the optical axis of the spectrograph. Unlike the earlier grating, the rulings of the new grating were apparently not curved, as indicated by the constancy of the focal setting for a given wave-length in the spectra of the various orders on either side of the normal. The second and third orders on one side were particularly brilliant, and the time required to photograph the spectrum was only 2 or 3 per cent of the exposure necessary with the earlier grating.

Many test spectrograms were made to determine the best instrumental conditions. With rather crude temporary mechanism difficulty was experienced in the adjustment of the prisms which reflected the light from opposite limbs through the slit of the spectrograph. The full width of the grating was usually easily filled with the light from both limbs, but irregularities in the adjustment along the lines of the grating frequently made it necessary to give slightly different times of exposure to the two limbs. However, the spectra were carefully focused to insure against displacements of the spectrum lines, which otherwise might result owing to a difference in the illumination of the grating from the two limbs.

Observations.—About 300 observations at $\lambda 4500$, recording a strip of spectrum from within the east limb between two strips from within the west limb, were made by Plaskett and De Lury observing together and singly. Nearly 200 of these were in the second order spectrum and the remainder in the third. They were taken at the equator and at intervals of 15° up to and including the poles. About 100 observations of the equatorial velocity displacements were made, and of these the 78 listed in Table IV were selected as suitable for measurement.

Measurements.—In 1910 the two observers measured some of the equatorial plates. These measurements¹ exhibited a large range of values of the rotational velocity and indicated the presence of certain systematic errors of measuring. The systematic difference between the measurements of the two observers persisted in the measurements of plates recording mechanical displacements of the spectrum lines² as well as in later

¹ Rept. Chief Astronomer, 1911, 129 and 262.

² *Ibid.* 268–281.

measurements of rotation plates³, and since the cause of the systematic errors was unknown in those earlier years the determinations of the equatorial velocity were uncertain by as much as 2 per cent.

Among the early measurements that of plate L569 (4) revealed something of the nature of the errors. On this plate the displacements of 70 spectrum lines were measured by making 4 settings on each line in each of the 3 strips of spectra, the image of the spectrum line being brought alternately from left and right to the setting on the fixed spider thread in the focal plane of the microscope. The means of all first, second, third, and fourth settings are as follows:—

70 spectrum lines, L569 (4),	Means of micrometer settings (mm.)			
	1st	2nd	3rd	4th
First strip, west limb.....	.5177	.5166	.5171	.5164
Excess over .5164.....	.0013	.0002	.0007	.0000
Second strip, east limb.....	.5739	.5723	.5727	.5722
Excess over .5722.....	.0017	.0001	.0005	.0000
Third strip, west limb.....	.5179	.5190	.5169	.5185
Excess over .5169.....	.0010	.0021	.0000	.0016
Three strips, means.....	.5365	.5360	.5356	.5357
Excess over .5356.....	.0009	.0004	.0000	.0001
East-west, mean displacements.....	.0561	.0545	.0557	.0547
		.0553		.0552

Thus, associated with the alternate left and right approach in the micrometer settings there was a systematic difference between the odd and even settings; and along with this peculiarity there was a gradual lessening of the readings, indicating a relative motion (progressing throughout the whole measurement of a spectrum line but more prominent in the measurement of the first two strips) between the spider thread and the image of the spectrum line. At the time, the possibility that this relative motion was caused by the face and breath of the measurer in warming the left side of the eye-piece support was considered, but check measurements made with the left eye revealed no change. Later, of course, the systematic errors were found to be due to capillary action of the oil between nut and micrometer thread, causing the plate to settle in one direction during about 3 minutes⁴.

In 1915-16, De Lury measured 32 of the second order plates of the equatorial rotation, since the $\lambda 4500$ region afforded a good selection of spectrum lines for testing the possible effect of level in the solar atmosphere on the rotational velocity displacements⁵. The spectrum lines measured were chosen (Table V and Fig. 1) after inspecting and measuring penumbral displacements in sunspot spectra observed in 1914. The strongest or most intense of these lines may be readily measured on plates of good density in the second order.

³ Astrophysical Journal, XXXVII, 87, 1913.

⁴ Pub. Dom. Obs. VI, Pt. I, 18-23.

⁵ Astrophys. J. XLIV, 186, 1916.

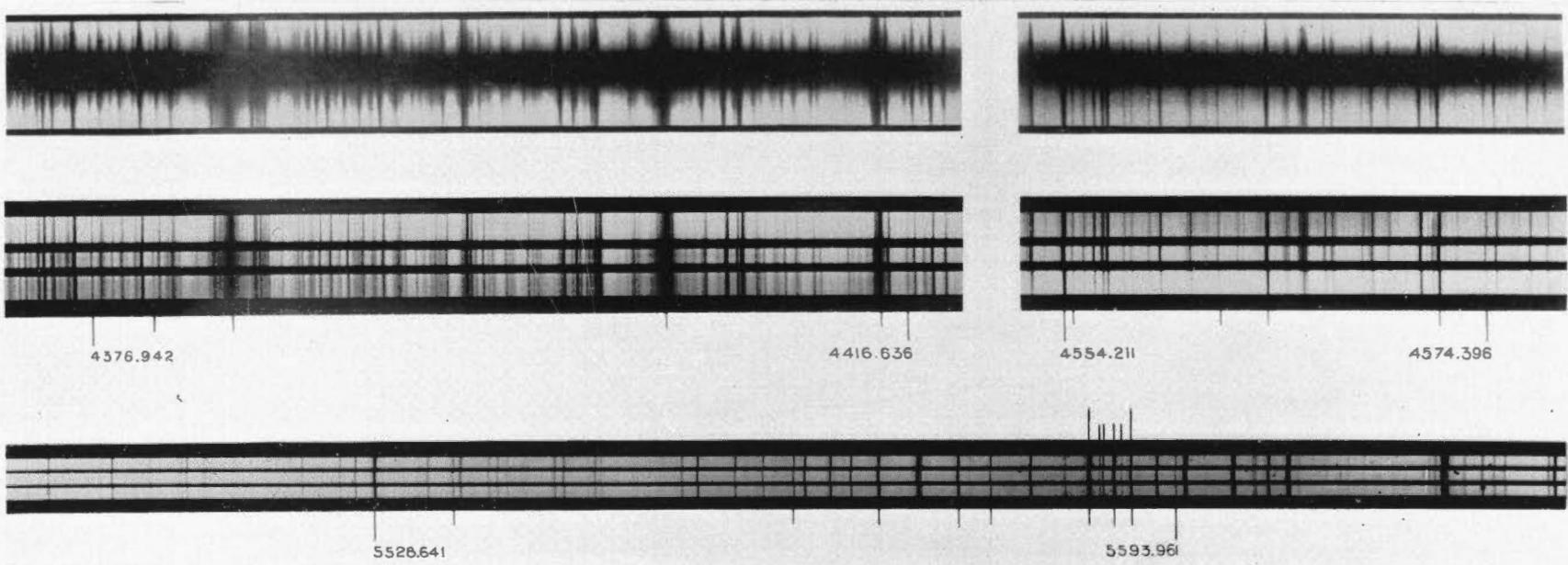


Figure 1—Above, sunspot spectra recording penumbral displacements, aligned with a spectrum of the east limb between spectra of the west limb recording rotational displacements, the spectrum lines measured in the $\lambda 4500$ region being indicated.

Below, a spectrum of the east limb between spectra of the west limb, the groups of spectrum lines used in measuring the rotational displacements in the $\lambda 5600$ region being indicated.

Half of the group of plates, namely L527 (1) to L554 (2), were measured in the usual way by making 4 settings on the central strip of the three, followed by 2 settings on each of the two outside strips. The remaining 16 spectrograms, L558 (1) to L578 (4), were measured with a similar number of settings, though on alternate lines the outside strips were measured first, beginning with the central strip first on alternate observations, so that each spectrum line was measured as many times with the central strip first as with the outside strips first in both the violet left and violet right positions of the plates. Individually, the measurements of the latter 16 revealed high and low values on alternate lines, but these differences were eliminated in the means; and it was evident that whatever was the cause of the systematic errors of measurement this procedure eliminated the errors. The measurements no longer showed the systematic difference between the violet left and violet right positions, the differences appearing to be accidental. These measurements virtually led to the discovery that the plate was actually in motion during measurement; and the micrometer oil was disclosed as the cause. By tightening the split nut the extent of the motion was lessened and the order in which the settings were made reduced any error due to this cause which remained or might develop in time. With these precautions, O'Connor repeated the measurements of the same group of 12 lines for each of the 32 observations. This repetition was particularly desirable in view of the fact that De Lury's measurements indicated no appreciable difference in rotational velocity for different levels in the solar atmosphere.

Table VI contains the measurements and derived velocities by both observers for the 32 observations; while Table VII contains similar results of 46 additional observations measured either violet left or violet right by O'Connor, using the second group of 6 spectrum lines on third order plates and on those additional second order plates of sufficient density to make this group of lines measurable.

The list of observations is given in Table IV in the form described in the preceding presentation of the observations of 1909. Table V, in addition to the Rowland wavelengths of the 12 spectrum lines selected for measurement, gives the international wavelengths, λ I.A., the element identifications, and the intensities in the spectra of the solar disc and of spots taken from the *Revision of Rowland's Preliminary Table of Solar Spectrum Wave-Lengths*⁶, and in columns headed "Flash" and "Height" the intensity and elevation in the chromosphere taken from *The Spectrum of the Chromosphere*⁷. Under "Penumbral Displacement", are given, in Å. and in km. per sec., the means of violet left and violet right measurements by De Lury of the displacements of 5 observations of sunspot spectra for each group of 6 lines, Plates L1517 and L1518. The bracketed value of "Height" for λ 4554·626 is inferred from these displacements. In the column headed "Scale" are given the values of Å. per mm. at each spectrum line determined from a scale curve derived from the measurements of plate L527. These values are about average for the group of second order plates, the greatest departure for any plate being about one part in 600; and to cover the range of scales for the various plates a supplementary table of velocity factors, F , was used, F being derived from the equation, $F \cdot \lambda = (\text{scale}) \times (\text{velocity of light})$. For the group of 6 lines measured on the third order plates the scale was

⁶ Charles E. St. John, et al.: Pub. No. 396, Carnegie Inst. of Washington; Papers of the Mt. Wilson Obs., Vol. III.

⁷ S. A. Mitchell, *Astrophys. J.* LXXI, pp. 1-62; Pub. Leander McCormick Obs., Vol. V, Part II.

practically constant at 0.6002 Å. per mm. In Tables VI and VII, containing the observed, measured, and computed data of the individual plates, the symbols used are the same as those defined in the preceding discussion of the 1909 observations, with the additions of d' denoting the measured displacements with the plate placed violet left, and d'' with plate violet right. Results for each observation are given in Table VI. Means of the observations on each plate are given in Table VII.

TABLE IV—RECORD OF OBSERVATIONS OF THE SOLAR ROTATION, $\lambda 4500$

Plate	1910		Position			Slit width	Exposure	Observing conditions and remarks		
	Date	E.S.T.	α	Disc	r			D	B	
L		h. m.	°	mm.	mm.					
493 (1), (2)	June 21	11 00	0	225.0	0.978	0.025	16	.....	.....	II order spectrum
497 (1), (2)	" 21	12 05	0	225.0	0.978	0.025	16	.....	.....	L497-L526, III order spectrum
502 (1), (2)	" 23	10 14	0	225.5	0.976	0.025	15	.....	.....
505 (1)	" 23	11 10	0	225.5	0.976	0.025	15	.....	.....
508 (3)	" 23	12 00	0	226.0	0.973	0.025	15	.....	.....
509 (1)	" 23	2 55	0	226.0	0.973	0.025	15	.....	.....	Unsteady
510 (1)	" 23	3 14	0	226.0	0.973	0.025	15	.....	.....	"
511 (1)-(4)	" 24	10 01	0	226.0	0.973	0.025	25	.....	.....	Various parts of grating used
512 (1)-(4)	" 24	11 00	0	226.0	0.973	0.025	25	.....	.....	" "
519 (1)-(4)	" 28	3 55	0	225.0	0.978	0.025	25	Good	.....
520 (1), (2)	" 28	4 24	0	225.0	0.978	0.025	25	.....	.....
522 (1), (2)	" 29	10 00	0	225.5	0.976	0.025	25	Fair	.....
525 (1), (2)	" 29	11 30	0	225.5	0.976	0.025	25	"	.....
526 (1), (2)	" 30	9 30	0	225.5	0.976	0.025	25	"	.....
527 (1), (2)	" 30	10 30	0	225.5	0.976	0.025	25	"	.....	L527-L578, II order spectrum
528 (1), (2)	July 5	10 38	0	226.0	0.973	0.025	25	"	.....	Brighter than previous smoky days
531 (1), (2)	" 5	2 46	0	226.0	0.973	0.025	25	"	.....
538 (1), (2)	" 11	10 20	0	225.5	0.931	0.025	20	"	.....
541 (1), (2)	" 11	11 35	0	225.5	0.931	0.025	17	Poorer	.....	Light clouds near sun
544 (1), (2)	" 12	10 54	0	225.0	0.933	0.025	20	Fair	.....
550 (1), (2)	" 13	10 27	0	225.0	0.933	0.025	23	Good	Clear	Fresh west wind
554 (1), (2)	" 13	11 43	0	225.0	0.933	0.025	23	Fair	.....
558 (1), (2)	" 14	9 55	0	226.0	0.973	0.025	23	Good	.....	Very steady
561 (3), (4)	" 14	10 40	0	225.5	0.976	0.025	22	Fair	.....
562 (1), (2)	" 14	11 30	0	225.5	0.976	0.025	22	"	.....
565 (3), (4)	" 14	12 18	0	225.5	0.976	0.025	25	Poor	Hazy	
566 (1), (2)	" 16	11 10	0	225.5	0.976	0.025	20	Good	.....
569 (3), (4)	" 16	12 31	0	225.5	0.976	0.025	20	Fair	.....
570 (1), (2)	" 19	10 59	0	226-	0.974	0.025	20	"	.....	Clouds intervened; (2) at 11.35
573 (1)-(4)	" 25	7 15	0	226.0	0.973	0.025	30	"	.....	Varying exposures
574 (1)-(4)	" 25	7 40	0	226.0	0.973	0.025	40	"	.....	" "
575 (1)-(4)	" 25	9 35	0	225.7	0.975	0.025	27	"	.....	" "
576 (1)-(4)	" 25	9 55	0	225.7	0.975	0.025	35	"	.....	" "
578 (1), (4)	" 25	10 25	0	225.7	0.975	0.025	33	"	.....

TABLE V—THE SPECTRUM LINES MEASURED AND THEIR VELOCITY FACTORS, F , FOR
1 mm. DISPLACEMENT

λ		Element	Intensity			Height	Penumbral displacement		II Order		III Order
Rowland	I.A.		Disc	Spot	Flash				Scale	F	F
Å						km.	Å	km./sec.	Å./mm.	km./sec.	
4376.942	.784	Fe-Cr	1	2	1d	400	0.026	1.76	0.9816	67.25	
4379.927	.771	Zr+Cr	0	1	2	400	0.029	2.01	0.9812	67.18	
4383.720s	.559	Fe	15	15	15	1600	-0.013	-0.91	0.9810	67.10	
4404.927s	.763	Fe	10	10	12	1200	-0.004	-0.30	0.9793	66.67	
4415.293s	.137	Fe	8	8	8	800	-0.003	-0.22	0.9784	66.45	
4416.636	.477	V	0	3	1	350	0.035	2.35	0.9783	66.42	
4554.211s	.038	Ba ⁺	8	10	50	2000	0.004	0.24	0.9732	64.08	39.55
4554.626	.462	Fe	1	2	.....	(400)	0.025	1.65	0.9732	64.07	39.55
4561.591	.419	.....	1	1	0	350	0.023	1.53	0.9726	63.94	39.46
4563.939s	.768	Ti ⁺	4	3	30	2500	0.005	0.32	0.9723	63.88	39.43
4572.156s	1.982	Ti ⁺	6	4	35	2500	0.006	0.38	0.9716	63.72	39.33
4574.396	.227	Fe	1	1	0	350	0.029	1.90	0.9713	63.67	39.30

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES

Plate:	L527 (1) June 30, 10:30, E.S.T.											
	$\alpha = 0^\circ \quad \beta = 6^\circ 7' \quad \gamma = 12^\circ 8'$ $r = 0.976 \quad \epsilon = 0.260 \quad \phi = 0^\circ 6'$ $B_o = 2.9 \quad 0.5127v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0512	1.851	1.898	0.0525	1.895	1.943	0.0485	1.761	1.806	0.0483	1.754	1.799
4379.927	0.0511	1.848	1.893	0.0530	1.910	1.959	0.0448	1.635	1.677	0.0487	1.766	1.811
4383.720	0.0477	1.732	1.774	0.0524	1.888	1.936	0.0490	1.774	1.819	0.0401	1.475	1.513
4404.927	0.0472	1.703	1.746	0.0482	1.737	1.781	0.0440	1.597	1.638	0.0463	1.673	1.716
4415.293	0.0520	1.857	1.904	0.0512	1.839	1.886	0.0480	1.725	1.769	0.0569	2.020	2.072
4416.636	0.0507	1.814	1.860	0.0479	1.721	1.765	0.0555	1.973	2.023	0.0494	1.771	1.816
4554.211	0.0549	1.889	1.937	0.0508	1.758	1.803	0.0523	1.706	1.750	0.0523	1.806	1.852
4554.626	0.0562	1.931	1.980	0.0509	1.761	1.806	0.0557	1.915	1.964	0.0541	1.863	1.911
4561.591	0.0575	1.968	2.018	0.0577	1.975	2.025	0.0560	1.820	1.866	0.0560	1.920	1.969
4563.939	0.0569	1.947	1.997	0.0528	1.816	1.862	0.0556	1.906	1.955	0.0525	1.807	1.853
4572.156	0.0514	1.768	1.813	0.0523	1.796	1.842	0.0545	1.866	1.914	0.0474	1.640	1.682
4574.396	0.0521	1.789	1.835	0.0496	1.709	1.753	0.0502	1.728	1.772	0.0518	1.779	1.824
Means:			1.888			1.863			1.829			1.818
						1.876						1.824

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L527 (2) June 30, 10:30, E.S.T.											
De L on T	$\alpha = 0^\circ \quad \beta = 6^\circ 7 \quad \gamma = 12^\circ 8$											
" "	$r = 0.976 \quad \epsilon = 0.260 \quad \phi = 0^\circ 6$											
O'C	$B_o = 2^\circ 9 \quad 0.5127v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0484	1.757	1.802	0.0473	1.720	1.764	0.0481	1.747	1.792	0.0479	1.740	1.784
4379.927	0.0517	1.867	1.915	0.0554	1.991	2.042	0.0563	2.021	2.073	0.0576	2.085	2.138
4383.720	0.0549	1.972	2.022	0.0469	1.703	1.746	0.0492	1.781	1.826	0.0468	1.700	1.743
4404.927	0.0505	1.813	1.859	0.0456	1.650	1.692	0.0539	1.926	1.975	0.0483	1.740	1.784
4415.293	0.0571	2.027	2.079	0.0534	1.904	1.953	0.0504	1.804	1.850	0.0477	1.715	1.759
4416.636	0.0488	1.751	1.796	0.0431	1.561	1.601	0.0459	1.657	1.699	0.0500	1.791	1.837
4554.211	0.0552	1.899	1.947	0.0516	1.783	1.828	0.0535	1.844	1.891	0.0521	1.799	1.845
4554.626	0.0470	1.636	1.678	0.0611	2.088	2.141	0.0562	1.931	1.980	0.0502	1.738	1.782
4561.591	0.0512	1.767	1.812	0.0497	1.719	1.763	0.0575	1.968	2.018	0.0591	2.019	2.071
4563.939	0.0540	1.855	1.902	0.0485	1.679	1.722	0.0535	1.839	1.886	0.0514	1.772	1.817
4572.156	0.0571	1.949	1.999	0.0567	1.936	1.985	0.0514	1.768	1.813	0.0495	1.707	1.751
4574.396	0.0494	1.703	1.746	0.0527	1.808	1.854	0.0535	1.833	1.880	0.0485	1.674	1.717
Means:			1.880			1.841			1.891			1.836
						1.861						1.864
Plate:	L528 (1) July 5, 10:38, E.S.T.											
De L on T	$\alpha = 0^\circ \quad \beta = 6^\circ 4 \quad \gamma = 13^\circ 8$											
" "	$r = 0.973 \quad \epsilon = 0.259 \quad \phi = 0^\circ 8$											
O'C.	$B_o = 3^\circ 4 \quad 0.5148v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0583	2.090	2.152	0.0521	1.882	1.938	0.0549	1.976	2.035	0.0479	1.740	1.792
4379.927	0.0576	2.064	2.125	0.0604	2.158	2.222	0.0500	1.809	1.863	0.0499	1.806	1.860
4383.720	0.0531	1.911	1.968	0.0508	1.834	1.888	0.0502	1.814	1.868	0.0534	1.922	1.979
4404.927	0.0591	2.099	2.161	0.0523	1.873	1.929	0.0524	1.876	1.932	0.0502	1.803	1.857
4415.293	0.0566	2.010	2.070	0.0578	2.050	2.111	0.0611	2.160	2.224	0.0531	1.894	1.950
4416.636	0.0589	2.085	2.147	0.0554	1.969	2.027	0.0576	2.043	2.104	0.0550	1.957	2.015
4554.211	0.0584	2.012	2.072	0.0591	2.035	2.095	0.0645	2.197	2.262	0.0642	2.187	2.252
4554.626	0.0618	2.122	2.185	0.0548	1.896	1.952	0.0634	2.161	2.225	0.0569	1.953	2.011
4561.591	0.0544	1.869	1.925	0.0505	1.744	1.796	0.0561	1.924	1.981	0.0521	1.796	1.849
4563.939	0.0613	2.087	2.149	0.0574	1.963	2.021	0.0588	2.008	2.068	0.0540	1.855	1.910
4572.156	0.0605	2.057	2.118	0.0553	1.891	1.947	0.0605	2.058	2.119	0.0668	2.258	2.325
4574.396	0.0560	1.912	1.969	0.0601	2.043	2.104	0.0597	2.031	2.091	0.0598	2.034	2.094
Means:			2.087			2.003			2.064			1.991
						2.045						2.028

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L528 (2) July 5, 10:39, E.S.T.											
De L on T " " O'C. " " " " "	$\alpha = 0^\circ \quad \beta = 6^\circ 4' \quad \gamma = 13^\circ 8'$ $r = 0.973 \quad \epsilon = 0.259 \quad \phi = 0^\circ 8'$ $B_0 = 3^\circ 4' \quad 0.5148v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376-942	0.0530	1.912	1.960	0.0525	1.895	1.951	0.0555	1.996	2.055	0.0520	1.878	1.934
4379-927	0.0545	1.960	2.018	0.0517	1.866	1.921	0.0494	1.789	1.842	0.0521	1.880	1.936
4383-720	0.0510	1.841	1.896	0.0516	1.861	1.916	0.0518	1.868	1.923	0.0451	1.643	1.692
4404-927	0.0602	2.136	2.199	0.0590	2.096	2.158	0.0570	2.030	2.090	0.0559	1.993	2.052
4415-293	0.0499	1.788	1.841	0.0532	1.897	1.953	0.0513	1.834	1.888	0.0533	1.901	1.957
4416-636	0.0601	2.125	2.188	0.0570	2.022	2.082	0.0574	2.036	2.096	0.0514	1.837	1.892
4554-211	0.0573	1.977	2.036	0.0580	2.000	2.059	0.0593	2.030	2.090	0.0527	1.819	1.873
4554-626	0.0644	2.206	2.272	0.0611	2.100	2.162	0.0626	2.136	2.199	0.0573	1.966	2.024
4561-591	0.0626	2.128	2.191	0.0627	2.135	2.198	0.0597	2.039	2.100	0.0572	1.959	2.017
4563-939	0.0560	1.919	1.976	0.0579	1.980	2.039	0.0529	1.820	1.874	0.0524	1.804	1.858
4572-156	0.0572	1.953	2.011	0.0580	1.978	2.037	0.0561	1.917	1.974	0.0536	1.838	1.893
4574-396	0.0594	2.022	2.082	0.0607	2.063	2.124	0.0596	2.028	2.088	0.0543	1.859	1.914
Means:		2.057			2.050			2.018			1.920	
					2.054						1.969	
	L531 (1) July 5, 2:45, E.S.T.											
De L. on T " " O'C. " " " " "	$\alpha = 0^\circ \quad \beta = 6^\circ 4' \quad \gamma = 13^\circ 8'$ $r = 0.973 \quad \epsilon = 0.259 \quad \phi = 0^\circ 8'$ $B_0 = 3^\circ 4' \quad 0.5148v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376-942	0.0550	1.979	2.038	0.0604	2.161	2.225	0.0599	2.144	2.208	0.0568	2.040	2.101
4379-927	0.0574	2.059	2.120	0.0518	1.870	1.926	0.0563	2.021	2.081	0.0587	2.108	2.171
4383-720	0.0543	1.952	2.010	0.0557	1.999	2.058	0.0527	1.898	1.954	0.0544	1.955	2.013
4404-927	0.0581	2.066	2.127	0.0551	1.966	2.024	0.0623	2.206	2.272	0.0537	1.920	1.977
4415-293	0.0596	2.110	2.173	0.0589	2.087	2.149	0.0540	1.924	1.981	0.0550	1.957	2.015
4416-636	0.0576	2.043	2.104	0.0598	2.116	2.179	0.0492	1.764	1.816	0.0502	1.797	1.850
4554-211	0.0598	2.049	2.110	0.0610	2.087	2.149	0.0534	1.841	1.896	0.0541	1.863	1.918
4554-626	0.0610	2.087	2.149	0.0592	2.030	2.090	0.0552	1.899	1.955	0.0547	1.883	1.939
4561-591	0.0542	1.863	1.918	0.0555	1.905	1.962	0.0566	1.940	1.998	0.0581	1.987	2.046
4563-939	0.0546	1.874	1.930	0.0552	1.894	1.950	0.0580	1.983	2.042	0.0562	1.925	1.982
4572-156	0.0594	2.023	2.083	0.0564	1.927	1.984	0.0581	1.981	2.040	0.0614	2.086	2.148
4574-396	0.0583	1.986	2.045	0.0578	1.970	2.029	0.0587	1.999	2.058	0.0590	2.009	2.069
Means:		2.067			2.060			2.025			2.019	
					2.064						2.022	

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:		L531 (2) July 5, 2:46, E.S.T.											
De L. on T		$\alpha = 0^\circ \quad \beta = 6^\circ 4' \quad \gamma = 13^\circ 8'$ $r = 0.973 \quad e = 0.259 \quad \phi = 0^\circ$ $B_0 = 3^\circ 4' \quad 0.5148v = V$											
λ		d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
		mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376·942		0.0570	2.046	2.107	0.0547	1.969	2.027	0.0534	1.925	1.982	0.0538	1.939	1.997
4379·927		0.0546	1.964	2.022	0.0547	1.967	2.025	0.0534	1.924	1.981	0.0576	2.065	2.126
4383·720		0.0569	2.039	2.100	0.0589	2.106	2.169	0.0550	1.975	2.034	0.0510	1.841	1.896
4404·927		0.0569	2.026	2.086	0.0547	1.953	2.011	0.0535	1.913	1.970	0.0513	1.840	1.895
4415·293		0.0560	1.990	2.049	0.0563	2.000	2.059	0.0575	2.040	2.101	0.0520	1.857	1.912
4416·636		0.0590	2.089	2.151	0.0629	2.219	2.285	0.0540	1.923	1.980	0.0470	1.691	1.741
4554·211		0.0583	2.001	2.060	0.0563	1.937	1.995	0.0587	2.011	2.070	0.0545	1.876	1.932
4554·626		0.0581	1.994	2.053	0.0591	2.027	2.087	0.0635	2.165	2.229	0.0544	1.873	1.929
4561·591		0.0574	1.966	2.024	0.0608	2.074	2.136	0.0604	2.061	2.122	0.0572	1.959	2.017
4563·939		0.0595	2.031	2.091	0.0593	2.025	2.085	0.0575	1.967	2.025	0.0552	1.893	1.949
4572·156		0.0598	2.036	2.096	0.0578	1.972	2.031	0.0615	2.089	2.151	0.0584	1.991	2.050
4574·396		0.0578	1.970	2.029	0.0598	2.034	2.094	0.0563	1.923	1.980	0.0555	1.897	1.953
Means:				2.072				2.084			2.052		
									2.078				2.001
Plate:		L538 (1) July 11, 10:18, E.S.T.											
De L. on T		$\alpha = 0^\circ \quad \beta = 6^\circ 0' \quad \gamma = 21^\circ 7'$ $r = 0.931 \quad e = 0.248 \quad \phi = 1^\circ 5'$ $B_0 = 4^\circ 0' \quad 0.5381v = V$											
λ		d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
		mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376·942		0.0540	1.940	2.088	0.0500	1.806	1.944	0.0484	1.751	1.885	0.0521	1.876	2.019
4379·927		0.0558	1.999	2.152	0.0481	1.740	1.873	0.0440	1.602	1.724	0.0432	1.575	1.695
4383·720		0.0513	1.846	1.987	0.0480	1.735	1.867	0.0497	1.791	1.928	0.0494	1.781	1.917
4404·927		0.0486	1.745	1.878	0.0527	1.881	2.025	0.0522	1.864	2.006	0.0490	1.757	1.891
4415·293		0.0469	1.683	1.811	0.0502	1.792	1.929	0.0475	1.702	1.832	0.0513	1.828	1.967
4416·636		0.0555	1.968	2.118	0.0555	1.968	2.118	0.0520	1.851	1.992	0.0481	1.721	1.852
4554·211		0.0563	1.928	2.075	0.0504	1.739	1.872	0.0471	1.633	1.758	0.0460	1.598	1.720
4554·626		0.0544	1.867	2.009	0.0546	1.873	2.016	0.0496	1.713	1.844	0.0517	1.780	1.916
4561·591		0.0491	1.694	1.823	0.0493	1.701	1.831	0.0533	1.828	1.967	0.0535	1.834	1.974
4563·939		0.0470	1.628	1.750	0.0473	1.635	1.760	0.0509	1.750	1.884	0.0440	1.529	1.646
4572·156		0.0490	1.686	1.815	0.0513	1.759	1.893	0.0449	1.555	1.674	0.0483	1.663	1.790
4574·396		0.0516	1.767	1.902	0.0467	1.611	1.734	0.0496	1.703	1.833	0.0484	1.665	1.792
Means:				1.951				1.905			1.861		
									1.928				1.855

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L538 (2) July 11, 10:19, E.S.T.											
De L. on T " " O'C. " " " "	$\alpha = 0^\circ \quad \beta = 6^\circ 0' \quad \gamma = 21^\circ 7'$ $r = 0.931 \quad \epsilon = 0.248 \quad \phi = 1^\circ 5'$ $B_0 = 4^\circ 0' \quad 0.5381v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0505	1.823	1.962	0.0505	1.823	1.962	0.0489	1.768	1.903	0.0514	1.852	1.993
4379.927	0.0500	1.804	1.942	0.0472	1.710	1.840	0.0480	1.736	1.868	0.0531	1.908	2.054
4383.720	0.0495	1.785	1.921	0.0457	1.647	1.773	0.0429	1.563	1.682	0.0457	1.657	1.783
4404.927	0.0508	1.818	1.957	0.0517	1.848	1.989	0.0480	1.724	1.856	0.0456	1.644	1.769
4415.293	0.0450	1.620	1.744	0.0431	1.556	1.675	0.0483	1.729	1.861	0.0443	1.596	1.718
4416.636	0.0421	1.523	1.639	0.0490	1.752	1.886	0.0467	1.675	1.803	0.0487	1.741	1.874
4554.211	0.0474	1.643	1.768	0.0449	1.563	1.682	0.0521	1.793	1.930	0.0500	1.726	1.858
4554.626	0.0528	1.816	1.955	0.0476	1.650	1.776	0.0520	1.790	1.927	0.0517	1.780	1.916
4561.591	0.0515	1.771	1.906	0.0483	1.669	1.796	0.0508	1.748	1.881	0.0535	1.834	1.974
4563.939	0.0479	1.655	1.781	0.0536	1.837	1.977	0.0531	1.820	1.959	0.0528	1.810	1.948
4572.156	0.0541	1.849	1.990	0.0539	1.842	1.983	0.0518	1.774	1.909	0.0504	1.730	1.862
4574.396	0.0480	1.653	1.779	0.0549	1.873	2.016	0.0550	1.875	2.018	0.0501	1.719	1.850
Means:		1.862			1.863			1.883			1.883	
					1.863						1.883	
Plate:	L541 (1) July 11, 11:33, E.S.T.											
De L. on T " " O'C. " " " "	$\alpha = 0^\circ \quad \beta = 6^\circ 0' \quad \gamma = 21^\circ 7'$ $r = 0.931 \quad \epsilon = 0.248 \quad \phi = 1^\circ 5'$ $B_0 = 4^\circ 0' \quad 0.5381v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0518	1.867	2.009	0.0509	1.837	1.977	0.0555	1.990	2.142	0.0537	1.929	2.076
4379.927	0.0565	2.023	2.177	0.0463	1.680	1.808	0.0515	1.854	1.995	0.0529	1.901	2.046
4383.720	0.0555	1.987	2.139	0.0511	1.840	1.980	0.0449	1.630	1.754	0.0442	1.607	1.730
4404.927	0.0542	1.932	2.079	0.0470	1.692	1.821	0.0474	1.704	1.834	0.0514	1.837	1.977
4415.293	0.0526	1.873	2.016	0.0485	1.736	1.868	0.0505	1.802	1.939	0.0538	1.911	2.057
4416.636	0.0488	1.746	1.879	0.0460	1.653	1.779	0.0489	1.748	1.881	0.0478	1.711	1.842
4554.211	0.0588	2.008	2.161	0.0499	1.723	1.854	0.0510	1.758	1.892	0.0442	1.540	1.658
4554.626	0.0595	2.030	2.185	0.0560	1.918	2.064	0.0531	1.825	1.964	0.0534	1.835	1.975
4561.591	0.0480	1.659	1.786	0.0472	1.633	1.758	0.0520	1.786	1.922	0.0490	1.691	1.820
4563.939	0.0567	1.936	2.084	0.0512	1.760	1.894	0.0582	1.983	2.134	0.0487	1.679	1.807
4572.156	0.0545	1.861	2.003	0.0472	1.628	1.752	0.0548	1.870	2.013	0.0461	1.593	1.715
4574.396	0.0515	1.764	1.899	0.0516	1.767	1.902	0.0519	1.776	1.912	0.0536	1.831	1.971
Means:		2.035			1.871			1.949			1.890	
					1.871						1.920	

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L541 (2) July 11, 11:34, E.S.T.											
De L. on T. " " O'C. " " " "	$\alpha = 0^\circ \quad \beta = 6^\circ 0' \quad \gamma = 21^\circ 7'$ $r = 0.931 \quad \epsilon = 0.248 \quad \phi = 1^\circ 6'$ $B_o = 4^\circ 0' \quad 0.5381v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0515	1.857	1.999	0.0520	1.874	2.017	0.0526	1.892	2.036	0.0460	1.671	1.798
4379.927	0.0561	2.009	2.162	0.0574	2.053	2.210	0.0515	1.854	1.995	0.0468	1.696	1.825
4383.720	0.0557	1.994	2.146	0.0556	1.991	2.143	0.0501	1.805	1.943	0.0580	2.070	2.228
4404.927	0.0591	2.095	2.255	0.0531	1.895	2.040	0.0516	1.844	1.985	0.0534	1.904	2.049
4415.293	0.0528	1.879	2.022	0.0499	1.783	1.919	0.0500	1.785	1.921	0.0547	1.941	2.089
4416.636	0.0564	1.998	2.150	0.0494	1.766	1.901	0.0497	1.775	1.910	0.0455	1.635	1.760
4554.211	0.0532	1.829	1.969	0.0546	1.874	2.017	0.0568	1.944	2.092	0.0533	1.832	1.972
4554.626	0.0563	1.928	2.075	0.0614	2.092	2.252	0.0590	2.014	2.168	0.0529	1.819	1.958
4561.591	0.0520	1.787	1.923	0.0523	1.797	1.934	0.0556	1.902	2.047	0.0535	1.834	1.974
4563.939	0.0552	1.888	2.032	0.0581	1.971	2.121	0.0530	1.817	1.956	0.0491	1.691	1.821
4572.156	0.0508	1.744	1.877	0.0563	1.919	2.065	0.0487	1.676	1.804	0.0524	1.793	1.930
4574.396	0.0556	1.895	2.040	0.0540	1.844	1.985	0.0524	1.792	1.929	0.0486	1.671	1.798
Means:		2.054			2.050			1.982			1.934	
					2.052						1.958	
Plate:	L544 (1) July 12, 10:54, E.S.T.											
De L. on T. " " O'C. " " " "	$\alpha = 0^\circ \quad \beta = 6^\circ 0' \quad \gamma = 21^\circ 5'$ $r = 0.933 \quad \epsilon = 0.249 \quad \phi = 1^\circ 5'$ $B_o = 4^\circ 1' \quad 0.5374v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0468	1.698	1.825	0.0441	1.607	1.727	0.0496	1.785	1.919	0.0504	1.818	1.954
4379.927	0.0548	1.965	2.112	0.0574	2.053	2.207	0.0542	1.945	2.090	0.0545	1.955	2.101
4383.720	0.0501	1.805	1.940	0.0488	1.762	1.894	0.0506	1.822	1.958	0.0464	1.681	1.807
4404.927	0.0497	1.781	1.914	0.0452	1.631	1.753	0.0559	1.987	2.136	0.0438	1.584	1.702
4415.293	0.0476	1.706	1.834	0.0411	1.490	1.601	0.0492	1.758	1.889	0.0438	1.579	1.697
4416.636	0.0559	1.981	2.129	0.0504	1.798	1.932	0.0535	1.801	1.936	0.0463	1.662	1.786
4554.211	0.0494	1.707	1.835	0.0508	1.752	1.883	0.0522	1.796	1.930	0.0527	1.813	1.949
4554.626	0.0539	1.851	1.989	0.0499	1.723	1.852	0.0524	1.803	1.938	0.0480	1.662	1.786
4561.591	0.0548	1.877	2.017	0.0514	1.768	1.900	0.0503	1.732	1.862	0.0511	1.758	1.889
4563.939	0.0523	1.796	1.930	0.0507	1.744	1.874	0.0550	1.881	2.022	0.0563	1.922	2.066
4572.156	0.0473	1.632	1.754	0.0474	1.635	1.757	0.0505	1.733	1.863	0.0530	1.813	1.949
4574.396	0.0459	1.586	1.705	0.0455	1.573	1.691	0.0512	1.754	1.885	0.0537	1.834	1.971
Means:		1.915			1.839			1.952			1.888	
					1.877						1.920	

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L544 (2) July 12, 10:55, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 6^\circ 0 \quad \gamma = 21^\circ 5$ $r = 0.933 \quad \epsilon = 0.249 \quad \phi = 1^\circ 5$ $B_0 = 4^\circ 1 \quad 0.5374v = V$											
O'C. "												
" "												
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376-942	0.0572	2.048	2.201	0.0551	1.977	2.125	0.0539	1.936	2.081	0.0530	1.906	2.049
4379-927	0.0476	1.723	1.852	0.0501	1.807	1.942	0.0531	1.908	2.051	0.0509	1.834	1.971
4383-720	0.0505	1.819	1.955	0.0535	1.919	2.063	0.0489	1.765	1.897	0.0515	1.852	1.991
4404-927	0.0569	2.021	2.172	0.0540	1.924	2.068	0.0525	1.874	2.014	0.0509	1.820	1.956
4415-293	0.0504	1.799	1.934	0.0534	1.898	2.040	0.0504	1.798	1.932	0.0502	1.792	1.926
4416-636	0.0524	1.865	2.005	0.0527	1.875	2.015	0.0489	1.748	1.879	0.0491	1.755	1.886
4554-211	0.0559	1.916	2.059	0.0569	1.948	2.094	0.0547	1.877	2.017	0.0528	1.816	1.952
4554-626	0.0501	1.730	1.859	0.0502	1.733	1.863	0.0569	1.947	2.093	0.0499	1.723	1.852
4561-591	0.0570	1.947	2.093	0.0539	1.848	1.986	0.0521	1.790	1.924	0.0580	1.978	2.126
4563-939	0.0506	1.741	1.871	0.0536	1.837	1.974	0.0522	1.791	1.925	0.0523	1.794	1.928
4572-156	0.0489	1.683	1.809	0.0460	1.590	1.709	0.0523	1.790	1.924	0.0491	1.688	1.814
4574-396	0.0570	1.939	2.084	0.0578	1.965	2.112	0.0533	1.821	1.957	0.0536	1.831	1.968
Means:		1.991			1.999			1.975			1.952	
					1.955						1.963	
Plate:	L550 (1) July 13, 10:27, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 9 \quad \gamma = 21^\circ 5$ $r = 0.933 \quad \epsilon = 0.249 \quad \phi = 1^\circ 6$ $B_0 = 4^\circ 2 \quad 0.5374v = V$											
O'C. "												
" "												
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376-942	0.0545	1.958	2.104	0.0516	1.860	1.999	0.0506	1.825	1.962	0.0484	1.751	1.882
4379-927	0.0572	2.046	2.199	0.0546	1.959	2.106	0.0533	1.914	2.057	0.0543	1.881	2.022
4383-720	0.0539	1.934	2.079	0.0508	1.930	2.074	0.0535	1.919	2.063	0.0479	1.731	1.860
4404-927	0.0639	2.256	2.425	0.0616	2.179	2.342	0.0561	1.994	2.143	0.0533	1.900	2.042
4415-293	0.0535	1.903	2.045	0.0535	1.903	2.045	0.0559	1.981	2.129	0.0496	1.772	1.905
4416-636	0.0554	1.965	2.112	0.0551	1.956	2.102	0.0501	1.788	1.922	0.0519	1.848	1.986
4554-211	0.0607	2.069	2.224	0.0613	2.089	2.245	0.0566	1.937	2.082	0.0544	1.867	2.007
4554-626	0.0530	1.823	1.959	0.0524	1.803	1.938	0.0546	1.873	2.013	0.0510	1.758	1.889
4561-591	0.0595	2.027	2.179	0.0553	1.892	2.034	0.0532	1.825	1.962	0.0544	1.863	2.002
4563-939	0.0576	1.965	2.112	0.0536	1.837	1.974	0.0528	1.810	1.945	0.0557	1.903	2.045
4572-156	0.0539	1.842	1.980	0.0537	1.836	1.973	0.0559	1.905	2.047	0.0574	1.953	2.099
4574-396	0.0598	2.029	2.181	0.0551	1.879	2.020	0.0564	1.920	2.064	0.0593	2.012	2.162
Means:		2.133			2.071			2.032			1.992	
					2.102						2.012	

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L550 (2) July 13, 10:28, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 9 \quad \gamma = 21^\circ 5$ $r = 0.933 \quad \epsilon = 0.249 \quad \phi = 1^\circ 6$ $B_o = 4^\circ 2 \quad 0.5374v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0550	1.975	2.123	0.0533	1.918	2.061	0.0525	1.889	2.030	0.0536	1.926	2.070
4379.927	0.0474	1.717	1.845	0.0530	1.905	2.047	0.0466	1.689	1.815	0.0511	1.840	1.978
4383.720	0.0513	1.847	1.985	0.0490	1.769	1.901	0.0498	1.795	1.929	0.0443	1.610	1.730
4404.927	0.0597	2.116	2.274	0.0511	1.829	1.966	0.0525	1.874	2.014	0.0465	1.674	1.799
4415.293	0.0622	2.192	2.356	0.0501	1.790	1.924	0.0473	1.695	1.822	0.0525	1.868	2.008
4416.636	0.0527	1.876	2.016	0.0514	1.833	1.970	0.0503	1.794	1.928	0.0473	2.027	2.179
4554.211	0.0551	1.890	2.031	0.0501	1.730	1.859	0.0551	1.889	2.030	0.0522	1.796	1.930
4554.626	0.0570	1.951	2.097	0.0533	1.832	1.969	0.0586	2.002	2.152	0.0540	1.854	1.993
4561.591	0.0544	1.864	2.003	0.0523	1.797	1.931	0.0546	1.870	2.010	0.0555	1.898	2.040
4563.939	0.0530	1.818	1.954	0.0611	2.077	2.232	0.0535	1.833	1.970	0.0471	1.628	1.750
4572.156	0.0555	1.893	2.035	0.0554	1.890	2.031	0.0577	1.962	2.109	0.0556	1.901	2.043
4574.396	0.0591	2.006	2.156	0.0581	1.974	2.122	0.0509	1.745	1.876	0.0511	1.751	1.882
Means:		2.073			2.001				1.974			1.950
					2.037							1.962
Plate:	L554 (1) July 13, 11:43, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 9 \quad \gamma = 21^\circ 5$ $r = 0.933 \quad \epsilon = 0.249 \quad \phi = 1^\circ 6$ $B_o = 4^\circ 2 \quad 0.5374v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0553	1.984	2.132	0.0535	1.923	2.067	0.0521	1.876	2.016	0.0517	1.862	2.001
4379.927	0.0533	1.915	2.058	0.0497	1.794	1.928	0.0581	2.076	2.231	0.0532	1.911	2.054
4383.720	0.0589	2.101	2.258	0.0558	1.997	2.146	0.0586	2.090	2.246	0.0508	1.828	1.965
4404.927	0.0548	1.951	2.097	0.0510	1.825	1.962	0.0559	1.987	2.135	0.0546	1.944	2.089
4415.293	0.0551	1.955	2.101	0.0539	1.915	2.058	0.0526	1.871	2.011	0.0565	2.001	2.151
4416.636	0.0574	2.031	2.183	0.0550	1.951	2.097	0.0513	1.828	1.965	0.0475	1.701	1.828
4554.211	0.0549	1.884	2.025	0.0569	1.948	2.094	0.0544	1.867	2.007	0.0517	1.780	1.913
4554.626	0.0562	1.925	2.069	0.0562	1.925	2.069	0.0585	1.998	2.147	0.0552	1.893	2.035
4561.591	0.0596	2.030	2.182	0.0537	1.841	1.979	0.0573	1.956	2.102	0.0519	1.783	1.916
4563.939	0.0586	1.997	2.146	0.0574	1.959	2.106	0.0560	1.913	2.056	0.0552	1.887	2.028
4572.156	0.0614	2.081	2.237	0.0557	1.900	2.042	0.0529	1.809	1.944	0.0545	1.860	1.999
4574.396	0.0593	2.013	2.164	0.0568	1.933	2.078	0.0547	1.866	2.006	0.0582	1.977	2.125
Means:		2.138			2.052				2.072			2.009
					2.095							2.041

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L554 (2) July 13, 11:44, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 9 \quad \gamma = 21^\circ 5$											
O'C. "	$r = 0.933 \quad e = 0.249 \quad \phi = 1^\circ 6$											
" "	$B_o = 4^\circ 2 \quad 0.5374v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376-942	0.0554	1.987	2.136	0.0588	2.102	2.259	0.0505	1.822	1.958	0.0534	1.919	2.063
4379-927	0.0596	2.127	2.286	0.0537	1.929	2.073	0.0507	1.827	1.964	0.0558	1.998	2.147
4383-720	0.0543	1.947	2.093	0.0496	1.789	1.923	0.0473	1.711	1.839	0.0547	1.959	2.106
4404-927	0.0660	2.325	2.499	0.0610	2.158	2.319	0.0591	2.094	2.251	0.0566	2.010	2.160
4415-293	0.0465	1.669	1.794	0.0557	1.975	2.123	0.0601	2.121	2.280	0.0572	2.024	2.175
4416-636	0.0550	1.951	2.097	0.0526	1.872	2.012	0.0561	1.987	2.136	0.0520	1.851	1.989
4554-211	0.0562	1.925	2.069	0.0539	1.851	1.989	0.0514	1.771	1.903	0.0536	1.841	1.979
4554-626	0.0546	1.874	2.014	0.0564	1.932	2.077	0.0560	1.918	2.061	0.0561	1.921	2.065
4561-591	0.0554	1.896	2.038	0.0587	2.001	2.151	0.0571	1.949	2.095	0.0609	2.071	2.226
4563-939	0.0595	2.026	2.178	0.0562	1.920	2.064	0.0556	1.900	2.042	0.0544	1.862	2.001
4572-156	0.0549	1.874	2.014	0.0577	1.963	2.110	0.0569	1.937	2.082	0.0495	1.701	1.828
4574-396	0.0565	1.924	2.068	0.0568	1.933	2.078	0.0512	1.754	1.885	0.0532	1.818	1.954
Means:		2.107			2.098			2.041			2.058	
					2.013						2.050	
Plate:	L558 (1) July 14, 9:54, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 8 \quad \gamma = 14^\circ 0$											
O'C. "	$r = 0.973 \quad e = 0.259 \quad \phi = 1^\circ 1$											
" "	$B_o = 4^\circ 3 \quad 0.5153v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376-942	0.0490	1.778	1.832	0.0503	1.822	1.878	0.0531	1.915	1.974	0.0525	1.895	1.953
4379-927	0.0532	1.918	1.977	0.0526	1.897	1.955	0.0535	1.927	1.986	0.0513	1.853	1.910
4383-720	0.0490	1.775	1.829	0.0461	1.678	1.729	0.0487	1.764	1.818	0.0520	1.875	1.932
4404-927	0.0527	1.888	1.948	0.0532	1.904	1.962	0.0556	1.983	2.044	0.0494	1.777	1.831
4415-293	0.0536	1.912	1.971	0.0552	1.965	2.025	0.0516	1.844	1.900	0.0560	1.990	2.051
4416-636	0.0553	1.968	2.028	0.0450	1.625	1.675	0.0612	2.162	2.228	0.0531	1.893	1.951
4554-211	0.0533	1.838	1.894	0.0545	1.876	1.933	0.0544	1.873	1.930	0.0595	2.036	2.098
4554-626	0.0618	2.110	2.175	0.0585	2.004	2.065	0.0541	1.863	1.920	0.0573	1.966	2.026
4561-591	0.0599	2.046	2.109	0.0552	1.895	1.953	0.0522	1.829	1.885	0.0555	1.904	1.962
4563-939	0.0567	1.942	2.001	0.0601	2.050	2.113	0.0540	1.855	1.912	0.0568	1.944	2.003
4572-156	0.0573	1.956	2.016	0.0535	1.835	1.891	0.0526	1.806	1.861	0.0565	1.930	1.989
4574-396	0.0547	1.872	1.929	0.0546	1.868	1.925	0.0586	1.996	2.057	0.0581	1.980	2.041
Means:		1.976			1.925			1.960			1.979	
					1.951						1.970	

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L558 (2) July 14, 9:55, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 8' \quad \gamma = 14^\circ 0'$ $r = 0.973 \quad \epsilon = 0.259 \quad \phi = 1^\circ 1'$ $B_o = 4^\circ 3' \quad 0.5153v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0542	1.953	2.013	0.0511	1.848	1.905	0.0541	1.949	2.009	0.0522	1.885	1.943
4379.927	0.0500	1.810	1.865	0.0432	1.582	1.630	0.0526	1.897	1.955	0.0496	1.796	1.851
4383.720	0.0538	1.936	1.995	0.0456	1.660	1.711	0.0502	1.814	1.870	0.0476	1.727	1.780
4404.927	0.0464	1.677	1.728	0.0484	1.737	1.790	0.0480	1.730	1.783	0.0483	1.740	1.793
4415.293	0.0554	1.971	2.031	0.0494	1.772	1.826	0.0514	1.838	1.894	0.0567	2.014	2.076
4416.636	0.0528	1.884	1.942	0.0476	1.711	1.763	0.0516	1.844	1.900	0.0494	1.771	1.825
4554.211	0.0574	1.970	2.030	0.0599	2.050	2.113	0.0580	1.988	2.049	0.0545	1.876	1.933
4554.626	0.0519	1.793	1.848	0.0566	1.944	2.003	0.0556	1.911	1.969	0.0552	1.899	1.957
4561.591	0.0505	1.745	1.798	0.0517	1.783	1.838	0.0534	1.837	1.893	0.0597	2.039	2.101
4563.939	0.0595	2.032	2.094	0.0568	1.945	2.005	0.0581	1.986	2.047	0.0537	1.846	1.902
4572.156	0.0581	1.982	2.043	0.0575	1.963	2.023	0.0600	2.042	2.104	0.0614	2.086	2.150
4574.396	0.0586	1.996	2.057	0.0622	2.111	2.176	0.0592	2.015	2.077	0.0560	1.913	1.972
Means:		1.954				1.899				1.963		1.940
						1.927						1.952
Plate:	L561 (3) July 14, 10:40, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 8' \quad \gamma = 13^\circ 3'$ $r = 0.976 \quad \epsilon = 0.260 \quad \phi = 1^\circ 0'$ $B_o = 4^\circ 3' \quad 0.5138v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0542	1.953	2.007	0.0457	1.667	1.713	0.0535	1.929	1.982	0.0507	1.835	1.886
4379.927	0.0440	1.608	1.652	0.0410	1.508	1.550	0.0484	1.756	1.804	0.0474	1.722	1.770
4383.720	0.0510	1.842	1.893	0.0520	1.889	1.941	0.0564	2.022	2.078	0.0478	1.734	1.782
4404.927	0.0568	2.024	2.080	0.0550	1.964	2.018	0.0510	1.830	1.881	0.0515	1.846	1.897
4415.293	0.0412	1.499	1.540	0.0465	1.675	1.721	0.0523	1.867	1.919	0.0508	1.818	1.868
4416.636	0.0556	1.977	2.032	0.0441	1.595	1.639	0.0540	1.923	1.976	0.0536	1.910	1.963
4554.211	0.0510	1.765	1.814	0.0537	1.851	1.902	0.0545	1.876	1.928	0.0580	1.988	2.043
4554.626	0.0583	1.999	2.054	0.0535	1.845	1.896	0.0556	1.911	1.964	0.0583	1.998	2.053
4561.591	0.0502	1.735	1.783	0.0567	1.943	1.997	0.0570	1.952	2.006	0.0527	1.815	1.865
4563.939	0.0578	1.977	2.032	0.0559	1.917	1.970	0.0560	1.919	1.972	0.0598	2.040	2.096
4572.156	0.0538	1.845	1.896	0.0537	1.842	1.893	0.0531	1.822	1.872	0.0595	2.026	2.082
4574.396	0.0578	1.971	2.025	0.0608	2.066	2.123	0.0545	1.865	1.916	0.0596	2.028	2.084
Means:		1.901				1.864				1.942		1.949
						1.883						1.946

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L561 (4) July 14, 10:41, E.S.T.											
De L. on T												
“ “	$\alpha = 0^\circ \quad \beta = 5^\circ 8' \quad \gamma = 13^\circ 3'$											
O'C. “	$r = 0.976 \quad \epsilon = 0.260 \quad \phi = 1^\circ 0'$											
“ “	$B_o = 4^\circ 3' \quad 0.5138v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0589	2.111	2.169	0.0517	1.869	1.921	0.0560	2.013	2.069	0.0537	1.935	1.988
4379.927	0.0516	1.864	1.915	0.0538	1.938	1.991	0.0554	1.991	2.046	0.0604	2.159	2.219
4383.720	0.0555	1.993	2.048	0.0443	1.617	1.662	0.0537	1.932	1.985	0.0470	1.707	1.754
4404.927	0.0575	2.047	2.103	0.0544	1.944	1.998	0.0582	2.070	2.127	0.0521	1.866	1.918
4415.293	0.0561	1.994	2.049	0.0585	2.074	2.131	0.0529	1.887	1.939	0.0516	1.844	1.895
4416.636	0.0605	2.140	2.199	0.0584	2.070	2.127	0.0477	1.714	1.761	0.0578	1.717	1.764
4554.211	0.0571	1.959	2.013	0.0539	1.857	1.908	0.0554	1.905	1.958	0.0540	1.860	1.911
4554.626	0.0543	1.870	1.922	0.0503	1.742	1.790	0.0609	2.081	2.138	0.0630	2.149	2.208
4561.591	0.0631	2.148	2.207	0.0634	2.158	2.218	0.0600	2.048	2.105	0.0657	2.230	2.292
4563.939	0.0599	2.044	2.100	0.0552	1.894	1.946	0.0564	1.931	1.984	0.0582	1.989	2.044
4572.156	0.0602	2.049	2.106	0.0620	2.106	2.164	0.0732	2.462	2.530	0.0632	2.144	2.203
4574.396	0.0606	2.060	2.117	0.0606	2.060	2.117	0.0596	2.028	2.084	0.0593	2.018	2.074
Means:		2.079			1.998				2.061			2.023
					2.039							2.041
Plate:	L562 (1) July 14, 11:30, E.S.T.											
De L. on T												
“ “	$\alpha = 0^\circ \quad \beta = 5^\circ 8' \quad \gamma = 13^\circ 3'$											
O'C. “	$r = 0.976 \quad \epsilon = 0.260 \quad \phi = 1^\circ 0'$											
“ “	$B_o = 4^\circ 3' \quad 0.5138v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0549	1.976	2.031	0.0481	1.748	1.796	0.0545	1.962	2.016	0.0553	1.989	2.044
4379.927	0.0590	2.112	2.170	0.0595	2.129	2.188	0.0565	2.028	2.084	0.0508	1.836	1.887
4383.720	0.0579	2.073	2.130	0.0567	2.033	2.089	0.0566	2.029	2.085	0.0524	1.888	1.940
4404.927	0.0567	2.020	2.076	0.0597	2.120	2.179	0.0561	2.000	2.055	0.0574	2.043	2.099
4415.293	0.0531	1.895	1.947	0.0548	1.951	2.005	0.0510	1.824	1.874	0.0542	1.931	1.984
4416.636	0.0464	1.671	1.717	0.0488	1.751	1.799	0.0481	1.727	1.775	0.0481	1.727	1.775
4554.211	0.0598	2.046	2.102	0.0604	2.065	2.122	0.0569	1.953	2.007	0.0546	1.879	1.931
4554.626	0.0668	2.270	2.333	0.0623	2.126	2.185	0.0605	2.068	2.125	0.0541	1.863	1.914
4561.591	0.0515	1.777	1.826	0.0503	1.739	1.787	0.0544	1.869	1.921	0.0520	1.792	1.841
4563.939	0.0566	1.938	1.991	0.0575	1.967	2.021	0.0539	1.852	1.903	0.0556	1.906	1.959
4572.156	0.0524	1.800	1.850	0.0529	1.816	1.866	0.0530	1.819	1.869	0.0526	1.806	1.856
4574.396	0.0529	1.814	1.864	0.0573	1.954	2.008	0.0546	1.868	1.920	0.0543	1.859	1.910
Means:		2.003			2.004				1.970			1.928
					2.004							1.949

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L562 (2) July 14, 11:30. E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \beta = 5^\circ 8' \gamma = 13^\circ 3'$ $r = 0.976 \epsilon = 0.260 \phi = 1^\circ 0'$ $B_0 = 4^\circ 3' 0.5138\pi = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376-942	0.0523	1.889	1.941	0.0461	1.680	1.726	0.0509	1.841	1.892	0.0519	1.875	1.927
4379-927	0.0534	1.924	1.977	0.0490	1.776	1.825	0.0519	1.873	1.925	0.0511	1.846	1.897
4383-720	0.0551	1.979	2.034	0.0570	2.043	2.099	0.0539	1.938	1.991	0.0518	1.868	1.920
4404-927	0.0523	1.874	1.926	0.0456	1.650	1.696	0.0555	1.980	2.035	0.0563	2.006	2.061
4415-293	0.0607	2.147	2.206	0.0545	1.941	1.995	0.0581	2.060	2.117	0.0546	1.944	1.998
4416-636	0.0490	1.758	1.807	0.0454	1.638	1.683	0.0441	1.595	1.639	0.0457	1.648	1.693
4554-211	0.0525	1.813	1.863	0.0530	1.829	1.879	0.0580	1.988	2.043	0.0532	1.835	1.886
4554-626	0.0557	1.915	1.968	0.0593	2.031	2.087	0.0588	2.014	2.070	0.0520	1.796	1.846
4561-591	0.0547	1.879	1.931	0.0567	1.943	1.997	0.0554	1.901	1.953	0.0474	1.645	1.690
4563-939	0.0570	1.952	2.006	0.0538	1.849	1.900	0.0527	1.813	1.863	0.0551	1.890	1.942
4572-156	0.0529	1.816	1.866	0.0536	1.839	1.890	0.0602	2.048	2.105	0.0550	1.882	1.934
4574-396	0.0532	1.824	1.874	0.0513	1.764	1.813	0.0556	1.900	1.952	0.0561	1.916	1.969
Means:		1.950			1.883			1.965			1.897	
					1.917						1.931	
Plate:	L565 (3) July 14, 12:18. E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \beta = 5^\circ 8' \gamma = 13^\circ 3'$ $r = 0.976 \epsilon = 0.260 \phi = 1^\circ 0'$ $B_0 = 4^\circ 3' 0.5138\pi = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376-942	0.0536	1.933	1.986	0.0506	1.832	1.883	0.0530	1.912	1.965	0.0547	1.969	2.023
4379-927	0.0572	2.052	2.109	0.0510	1.844	1.895	0.0521	1.880	1.932	0.0445	1.625	1.670
4383-720	0.0585	2.094	2.152	0.0547	1.966	2.020	0.0523	1.885	1.937	0.0491	1.777	1.826
4404-927	0.0576	2.051	2.108	0.0549	1.961	2.015	0.0596	2.116	2.174	0.0611	2.166	2.226
4415-293	0.0498	1.785	1.834	0.0499	1.789	1.838	0.0505	1.808	1.858	0.0555	1.974	2.028
4416-636	0.0496	1.778	1.827	0.0462	1.665	1.711	0.0497	1.781	1.830	0.0483	1.734	1.782
4554-211	0.0544	1.874	1.926	0.0573	1.966	2.020	0.0593	2.030	2.086	0.0569	1.953	2.007
4554-626	0.0569	1.954	2.008	0.0566	1.944	1.998	0.0565	1.940	1.994	0.0589	2.017	2.073
4561-591	0.0552	1.895	1.947	0.0528	1.819	1.869	0.0589	2.013	2.069	0.0524	1.805	1.855
4563-939	0.0600	2.048	2.015	0.0650	2.207	2.268	0.0498	1.721	1.768	0.0614	2.091	2.149
4572-156	0.0584	1.992	2.047	0.0576	1.966	2.020	0.0584	1.991	2.046	0.0581	1.981	2.036
4574-396	0.0545	1.866	1.918	0.0535	1.834	1.885	0.0529	1.814	1.864	0.0550	1.881	1.933
Means:		1.997			1.952			1.960			1.967	
					1.975						1.964	

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L565 (4) July 14, 12:18, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 8' \quad \gamma = 13^\circ 3'$											
O'C. "	$r = 0.976 \quad \epsilon = 0.260 \quad \phi = 1^\circ 1'$											
" "	$B_o = 4^\circ 3' \quad 0.5138v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0548	1.973	2.027	0.0517	1.869	1.921	0.0502	1.818	1.868	0.0507	1.835	1.886
4379.927	0.0544	1.958	2.012	0.0539	1.941	1.995	0.0502	1.816	1.866	0.0485	1.759	1.808
4383.720	0.0508	1.835	1.886	0.0491	1.772	1.821	0.0503	1.818	1.868	0.0513	1.851	1.902
4404.927	0.0527	1.888	1.940	0.0523	1.874	1.926	0.0443	1.607	1.651	0.0502	1.803	1.853
4415.293	0.0562	1.998	2.053	0.0529	1.888	1.940	0.0510	1.824	1.874	0.0515	1.841	1.892
4416.636	0.0553	1.968	2.022	0.0501	1.795	1.845	0.0550	1.957	2.011	0.0565	2.006	2.061
4554.211	0.0597	2.043	2.099	0.0540	1.860	1.911	0.0540	1.860	1.911	0.0567	1.947	2.001
4554.626	0.0495	1.716	1.763	0.0531	1.831	1.882	0.0506	1.751	1.799	0.0551	1.895	1.947
4561.591	0.0586	2.003	2.058	0.0584	1.997	2.052	0.0578	1.978	2.033	0.0561	1.924	1.977
4563.939	0.0600	2.046	2.102	0.0519	1.788	1.837	0.0544	1.868	1.920	0.0521	1.794	1.844
4572.156	0.0584	1.991	2.046	0.0555	1.898	1.950	0.0558	1.908	1.961	0.0567	1.936	1.989
4574.396	0.0617	2.095	2.153	0.0574	1.958	2.012	0.0518	1.779	1.828	0.0563	1.923	1.976
Means:		2.013			1.924				1.883			1.928
						1.969						1.906
Plate:	L566 (1) July 16, 11:10, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 7' \quad \gamma = 13^\circ 3'$											
O'C. "	$r = 0.976 \quad \epsilon = 0.260 \quad \phi = 1^\circ 1'$											
" "	$B_o = 4^\circ 5' \quad 0.5138v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0529	1.910	1.963	0.0514	1.859	1.910	0.0551	1.982	2.037	0.0561	2.016	2.072
4379.927	0.0565	2.028	2.084	0.0513	1.854	1.905	0.0504	1.823	1.873	0.0541	1.947	2.001
4383.720	0.0481	1.745	1.793	0.0435	1.590	1.634	0.0556	1.995	2.050	0.0505	1.824	1.874
4404.927	0.0562	2.004	2.059	0.0489	1.694	1.741	0.0466	1.683	1.729	0.0507	1.820	1.870
4415.293	0.0502	1.799	1.849	0.0504	1.805	1.855	0.0560	1.990	2.045	0.0543	1.934	1.987
4416.636	0.0562	1.998	2.053	0.0484	1.672	1.718	0.0483	1.734	1.782	0.0511	1.827	1.877
4554.211	0.0510	1.765	1.814	0.0512	1.771	1.820	0.0553	1.902	1.954	0.0531	1.831	1.882
4554.626	0.0542	1.867	1.919	0.0601	2.056	2.113	0.0567	1.947	2.001	0.0563	1.934	1.987
4561.591	0.0567	1.943	1.997	0.0563	1.930	1.983	0.0504	1.741	1.789	0.0545	1.872	1.924
4563.939	0.0553	1.897	1.949	0.0600	2.048	2.105	0.0529	1.820	1.870	0.0534	1.836	1.887
4572.156	0.0520	1.788	1.837	0.0492	1.698	1.745	0.0529	1.815	1.865	0.0516	1.774	1.823
4574.396	0.0519	1.783	1.832	0.0539	1.847	1.898	0.0569	1.942	1.996	0.0547	1.872	1.924
Means:		1.929			1.869				1.916			1.926
					1.899							1.921

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L566 (2) July 16, 11·10, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 7' \quad \gamma = 13^\circ 3'$											
O'C. "	$r = 0.976 \quad \epsilon = 0.260 \quad \phi = 1^\circ 1'$											
" "	$B_o = 4^\circ 5' \quad 0.5138v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376·942	0.0541	1.950	2.004	0.0572	2.054	2.111	0.0599	2.144	2.203	0.0535	1.929	1.982
4379·927	0.0482	1.750	1.798	0.0496	1.797	1.847	0.0512	1.850	1.901	0.0480	1.742	1.790
4383·720	0.0531	1.913	1.966	0.0529	1.906	1.959	0.0565	2.026	2.082	0.0582	2.083	2.140
4404·927	0.0571	2.034	2.090	0.0657	2.321	2.385	0.0579	2.060	2.117	0.0508	1.823	1.873
4415·293	0.0533	1.902	1.954	0.0537	1.915	1.968	0.0559	1.987	2.042	0.0564	2.004	2.059
4416·636	0.0595	2.107	2.165	0.0565	2.007	2.062	0.0573	2.033	2.089	0.0554	1.970	2.024
4554·211	0.0529	1.825	1.875	0.0569	1.954	2.008	0.0588	2.014	2.070	0.0511	1.767	1.816
4554·626	0.0537	1.851	1.902	0.0559	1.922	1.975	0.0558	1.918	1.971	0.0515	1.780	1.829
4561·591	0.0596	2.036	2.092	0.0622	2.119	2.177	0.0536	1.844	1.895	0.0565	1.936	1.989
4563·939	0.0559	1.917	1.970	0.0611	2.083	2.140	0.0569	1.947	2.001	0.0535	1.839	1.890
4572·156	0.0552	1.890	1.942	0.0587	2.001	2.056	0.0588	2.003	2.058	0.0542	1.857	1.908
4574·396	0.0585	1.993	2.048	0.0592	2.016	2.072	0.0579	1.974	2.028	0.0543	1.859	1.910
Means:		1.984			2.063				2.038			1.934
					2.024							1.986
Plate:	L569 (3) July 16, 12·31, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 7' \quad \gamma = 13^\circ 3'$											
O'C. "	$r = 0.976 \quad \epsilon = 0.260 \quad \phi = 1^\circ 1'$											
" "	$B_o = 4^\circ 5' \quad 0.5138v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376·942	0.0534	1.928	1.979	0.0566	2.034	2.090	0.0531	1.915	1.968	0.0563	2.023	2.079
4379·927	0.0570	2.045	2.101	0.0536	1.931	1.984	0.0634	2.260	2.322	0.0607	2.169	2.229
4383·720	0.0551	1.980	2.035	0.0550	1.976	2.031	0.0564	2.022	2.078	0.0507	1.831	1.882
4404·927	0.0522	1.871	1.923	0.0525	1.881	1.933	0.0569	2.026	2.082	0.0521	1.866	1.918
4415·293	0.0539	1.922	1.975	0.0543	1.935	1.988	0.0516	1.844	1.895	0.0545	1.940	1.994
4416·636	0.0599	2.120	2.179	0.0616	2.177	2.237	0.0535	1.907	1.960	0.0529	1.887	1.939
4554·211	0.0536	1.848	1.899	0.0552	1.899	1.951	0.0554	1.905	1.958	0.0529	1.825	1.875
4554·626	0.0555	1.909	1.962	0.0519	1.793	1.842	0.0549	1.889	1.941	0.0528	1.822	1.872
4561·591	0.0569	1.950	2.004	0.0550	1.889	1.941	0.0525	2.128	2.187	0.0619	2.109	2.167
4563·939	0.0638	2.169	2.229	0.0611	2.083	2.140	0.0576	1.970	2.024	0.0591	2.018	2.074
4572·156	0.0563	1.925	1.978	0.0560	1.915	1.968	0.0617	2.096	2.154	0.0581	1.981	2.036
4574·396	0.0535	1.834	1.885	0.0479	1.656	1.702	0.0579	1.974	2.028	0.0571	1.948	2.002
Means:		2.012			1.984				2.050			2.006
					1.998							2.028

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L569 (4) July 16, 12:31, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 7 \quad \gamma = 13^\circ 3$ $r = 0.976 \quad \epsilon = 0.260 \quad \phi = 1^\circ 1$ $B_0 = 4^\circ 5 \quad 0.5138v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0518	1.873	1.925	0.0485	1.762	1.811	0.0487	1.767	1.816	0.0542	1.952	2.006
4379.927	0.0444	1.622	1.667	0.0446	1.629	1.674	0.0480	1.742	1.790	0.0572	2.051	2.108
4383.720	0.0474	1.721	1.768	0.0545	1.960	2.014	0.0557	1.999	2.054	0.0504	1.821	1.871
4404.927	0.0515	1.848	1.899	0.0539	1.928	1.981	0.0579	2.060	2.117	0.0535	1.913	1.966
4415.293	0.0556	1.978	2.033	0.0514	1.839	1.890	0.0534	1.904	1.957	0.0500	1.791	1.840
4416.636	0.0532	1.898	1.950	0.0553	1.968	2.022	0.0550	1.957	2.011	0.0525	1.907	1.960
4554.211	0.0567	1.947	2.001	0.0579	1.986	2.041	0.0594	2.033	2.089	0.0536	1.847	1.898
4554.626	0.0587	2.011	2.067	0.0515	1.781	1.830	0.0504	1.745	1.793	0.0550	1.892	1.944
4561.591	0.0546	1.876	1.928	0.0563	1.930	1.983	0.0563	1.930	1.983	0.0530	1.824	1.874
4563.939	0.0580	1.984	2.039	0.0659	2.236	2.298	0.0559	1.915	1.968	0.0556	1.906	1.959
4572.156	0.0484	1.673	1.719	0.0565	1.931	1.984	0.0565	1.930	1.983	0.0523	1.796	1.846
4574.396	0.0522	1.793	1.842	0.0518	1.780	1.829	0.0535	1.833	1.884	0.0559	1.910	1.963
Means:		1.903			1.946			1.954			1.936	
					1.925						1.945	
Plate:	L570 (1) July 19, 10:59, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \quad \beta = 5^\circ 4 \quad \gamma = 13^\circ 8$ $r = 0.974 \quad \epsilon = 0.260 \quad \phi = 1^\circ 2$ $B_0 = 4^\circ 8 \quad 0.5149v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0509	1.842	1.897	0.0523	1.889	1.945	0.0531	1.915	1.972	0.0513	1.855	1.910
4379.927	0.0519	1.874	1.930	0.0493	1.786	1.839	0.0476	1.729	1.780	0.0534	1.924	1.981
4383.720	0.0454	1.654	1.703	0.0503	1.819	1.873	0.0524	1.888	1.944	0.0481	1.744	1.796
4404.927	0.0485	1.747	1.799	0.0545	1.948	2.006	0.0511	1.833	1.887	0.0496	1.783	1.836
4415.293	0.0456	1.646	1.695	0.0481	1.729	1.780	0.0549	1.954	2.012	0.0462	1.665	1.714
4416.636	0.0526	1.878	1.934	0.0529	1.888	1.944	0.0439	1.588	1.635	0.0490	1.757	1.809
4554.211	0.0533	1.838	1.893	0.0518	1.790	1.843	0.0506	1.751	1.803	0.0521	1.799	1.852
4554.626	0.0455	1.588	1.635	0.0605	2.068	2.129	0.0559	1.921	1.978	0.0555	1.908	1.965
4561.591	0.0509	1.750	1.802	0.0522	1.799	1.852	0.0560	1.920	1.977	0.0501	1.732	1.783
4563.939	0.0476	1.651	1.700	0.0549	1.884	1.940	0.0513	1.769	1.822	0.0518	1.778	1.831
4572.156	0.0566	1.934	1.991	0.0574	1.959	2.017	0.0506	1.742	1.794	0.0521	1.790	1.843
4574.396	0.0517	1.776	1.829	0.0528	1.811	1.865	0.0530	1.818	1.872	0.0540	1.849	1.904
Means:		1.817			1.919			1.873			1.852	
					1.868						1.863	

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Continued

Plate:	L570 (2) July 19, 11:35, E.S.T.											
De L. on T												
" "												
O'C. " "	$\alpha = 0^\circ \quad \beta = 5^\circ 4' \quad \gamma = 13^\circ 8'$ $r = 0.974 \quad \epsilon = 0.260 \quad \phi = 1^\circ 2'$ $B_0 = 4^\circ 8' \quad 0.5149v = V$											
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0519	1.876	1.932	0.0428	1.570	1.617	0.0541	1.949	2.007	0.0531	1.915	1.972
4379.927	0.0418	1.534	1.580	0.0424	1.555	1.601	0.0505	1.826	1.880	0.0469	1.705	1.756
4383.720	0.0457	1.664	1.713	0.0496	1.795	1.848	0.0476	1.727	1.778	0.0470	1.707	1.758
4404.927	0.0531	1.901	1.957	0.0564	2.011	2.071	0.0526	1.883	1.939	0.0501	1.800	1.853
4415.293	0.0491	1.762	1.814	0.0545	1.942	2.000	0.0493	1.768	1.821	0.0492	1.764	1.816
4416.636	0.0479	1.722	1.773	0.0467	1.682	1.732	0.0579	2.053	2.114	0.0565	2.006	2.066
4554.211	0.0514	1.777	1.830	0.0525	1.812	1.866	0.0503	1.742	1.794	0.0462	1.610	1.658
4554.626	0.0479	1.665	1.714	0.0474	1.649	1.698	0.0540	1.860	1.915	0.0491	1.703	1.754
4561.591	0.0518	1.787	1.840	0.0542	1.863	1.918	0.0492	1.703	1.754	0.0565	1.937	1.995
4563.939	0.0471	1.635	1.684	0.0539	1.852	1.907	0.0511	1.762	1.814	0.0534	1.836	1.891
4572.156	0.0532	1.825	1.879	0.0559	1.912	1.969	0.0567	1.936	1.993	0.0485	1.675	1.725
4574.396	0.0512	1.760	1.812	0.0495	1.706	1.757	0.0507	1.744	1.796	0.0502	1.728	1.779
Means:		1.794				1.832			1.884			1.835
						1.813						1.860
Plate:	L578 (1) July 25, 10:23, E.S.T.											
De L. on T												
" "												
O'C. " "	$\alpha = 0^\circ \quad \beta = 4^\circ 9' \quad \gamma = 13^\circ 8'$ $r = 0.975 \quad \epsilon = 0.260 \quad \phi = 1^\circ 2'$ $B_0 = 5^\circ 3' \quad 0.5149v = V$											
λ	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0508	1.839	1.894	0.0502	1.819	1.873	0.0488	1.771	1.824	0.0501	1.814	1.868
4379.927	0.0504	1.823	1.877	0.0515	1.860	1.915	0.0520	1.877	1.933	0.0542	1.951	2.009
4383.720	0.0437	1.597	1.644	0.0557	2.000	2.059	0.0465	1.690	1.740	0.0481	1.744	1.796
4404.927	0.0533	1.908	1.965	0.0481	1.734	1.785	0.0508	1.823	1.877	0.0545	1.946	2.004
4415.293	0.0613	2.168	2.232	0.0551	1.962	2.020	0.0548	1.950	2.008	0.0513	1.834	1.888
4416.636	0.0621	2.194	2.259	0.0576	2.044	2.105	0.0529	1.887	1.943	0.0546	1.943	2.001
4554.211	0.0524	1.809	1.863	0.0537	1.851	1.906	0.0539	1.857	1.912	0.0559	1.921	1.978
4554.626	0.0556	1.911	1.968	0.0585	2.004	2.064	0.0596	2.040	2.101	0.0556	1.911	1.968
4561.591	0.0534	1.838	1.893	0.0574	1.966	2.024	0.0575	1.968	2.026	0.0565	1.936	1.993
4563.939	0.0584	1.996	2.055	0.0539	1.852	1.907	0.0555	1.903	1.960	0.0596	2.034	2.094
4572.156	0.0529	1.816	1.870	0.0561	1.918	1.975	0.0538	1.844	1.899	0.0528	1.812	1.866
4574.396	0.0557	1.903	1.960	0.0512	1.760	1.812	0.0515	1.770	1.823	0.0569	1.942	2.000
Means:		1.957				1.954			1.921			1.955
						1.956						1.938

TABLE VI—RESULTS FROM INDIVIDUAL OBSERVATIONS, 12 SPECTRUM LINES—Concluded

Plate:	L578 (4) July 25, 10:26, E.S.T.											
De L. on T												
" "	$\alpha = 0^\circ \beta = 4^\circ 9 \gamma = 13^\circ 8$ $r = 0.975 \epsilon = 0.260 \phi = 1^\circ 2$ $B_0 = 5^\circ 3 \quad 0.5149v = V$											
O'C. "												
" "												
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4376.942	0.0527	1.903	1.960	0.0498	1.805	1.859	0.0470	1.710	1.761	0.0561	2.016	2.076
4379.927	0.0512	1.850	1.905	0.0485	1.760	1.812	0.0576	2.065	2.126	0.0484	1.756	1.808
4383.720	0.0561	2.013	2.073	0.0567	2.033	2.093	0.0490	1.774	1.827	0.0446	1.626	1.674
4404.927	0.0539	1.928	1.985	0.0583	2.074	2.136	0.0597	2.120	2.183	0.0533	1.906	1.963
4415.203	0.0461	1.662	1.711	0.0526	1.878	1.934	0.0494	1.771	1.824	0.0581	2.060	2.121
4416.636	0.0568	2.017	2.077	0.0474	1.705	1.756	0.0494	1.771	1.824	0.0506	1.810	1.864
4554.211	0.0536	1.848	1.903	0.0545	1.877	1.933	0.0511	1.767	1.819	0.0531	1.831	1.885
4554.626	0.0493	1.710	1.761	0.0559	1.922	1.979	0.0522	1.802	1.856	0.0527	1.819	1.873
4561.591	0.0556	1.908	1.965	0.0547	1.879	1.935	0.0518	1.786	1.839	0.0548	1.882	1.938
4563.939	0.0524	1.805	1.859	0.0557	1.910	1.967	0.0492	1.701	1.752	0.0541	1.858	1.913
4572.156	0.0508	1.750	1.802	0.0542	1.858	1.913	0.0539	1.847	1.902	0.0525	1.803	1.857
4574.396	0.0524	1.799	1.852	0.0522	1.793	1.846	0.0547	1.872	1.928	0.0538	1.843	1.898
Means:		1.904				1.930			1.887			1.906
						1.917						1.897

TABLE VII—RESULTS FROM INDIVIDUAL OBSERVATIONS, 6 SPECTRUM LINES

Plate:	L493 (1)-(2) June 21, 11.00 E.S.T.	L497 (1)-(2) June 21, 12.05 E.S.T.	L502 (1)-(2) June 23, 10.14, E.S.T.	L505 (1) June 23, 11.10, E.S.T.								
O'C. on T	$\alpha=0^\circ \beta=7^\circ 0 \gamma=12^\circ 2$ $r=0.978 \epsilon=0.260 \phi=0^\circ 3$ $B_0=1^\circ 9 \quad 0.5116v = V$	$\alpha=0^\circ \beta=7^\circ 0 \gamma=12^\circ 2$ $r=0.978 \epsilon=0.260 \phi=0^\circ 3$ $B_0=1^\circ 9 \quad 0.5116v = V$	$\alpha=0^\circ \beta=6^\circ 9 \gamma=12^\circ 8$ $r=0.976 \epsilon=0.260 \phi=0^\circ 4$ $B_0=2^\circ 1 \quad 0.5127v = V$	$\alpha=0^\circ \beta=6^\circ 9 \gamma=12^\circ 8$ $r=0.976 \epsilon=0.260 \phi=0^\circ 4$ $B_0=2^\circ 1 \quad 0.5127v = V$								
λ	d''	$\frac{1}{2}v$	V	d''								
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4554.211	0.0562	1.929	1.974	0.0841	1.793	1.835	0.0813	1.738	1.782	0.0832	1.775	1.820
4554.626	0.0583	2.012	2.059	0.0881	1.872	1.915	0.0932	1.975	2.025	0.0866	1.843	1.890
4561.626	0.0556	2.064	2.112	0.0908	1.921	1.966	0.0912	1.930	1.980	0.0984	2.072	2.125
4563.939	0.0557	1.938	1.983	0.0801	1.709	1.748	0.0844	1.796	1.841	0.0863	1.831	1.878
4572.156	0.0567	1.935	1.980	0.0874	1.849	1.891	0.0830	1.762	1.807	0.0850	1.801	1.847
4574.396	0.0555	1.895	1.939	0.0846	1.791	1.832	0.0813	1.730	1.773	0.0801	1.704	1.747
Means:		2.008		1.864			1.868				1.887	

TABLE VII—RESULTS FROM INDIVIDUAL OBSERVATIONS, 6 SPECTRUM LINES—Continued

Plate:	L508 (3) June 23, 12.00, E.S.T.			L509 (1) June 23, 2.55, E.S.T.			L510 (1) June 23, 3.14, E.S.T.			L511 (1)–(4) June 24, 10.01, E.S.T.		
O'C. on T	$\alpha=0^\circ \beta=6^\circ 9 \gamma=13^\circ 5$ $r=0.973 \epsilon=0.259 \phi=0^\circ 5$ $B_o=2^\circ 1 0.5142v = V$	$\alpha=0^\circ \beta=6^\circ 9 \gamma=13^\circ 5$ $r=0.973 \epsilon=0.259 \phi=0^\circ 5$ $B_o=2^\circ 1 0.5142v = V$	$\alpha=0^\circ \beta=6^\circ 9 \gamma=13^\circ 5$ $r=0.973 \epsilon=0.259 \phi=0^\circ 5$ $B_o=2^\circ 1 0.5142v = V$	$\alpha=0^\circ \beta=6^\circ 9 \gamma=13^\circ 5$ $r=0.973 \epsilon=0.259 \phi=0^\circ 5$ $B_o=2^\circ 2 0.5142v = V$								
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
4554-211	mm. 0.0710	km./sec. 1.529	km./sec. 1.572	mm. 0.0843	km./sec. 1.796	km./sec. 1.847	mm. 0.0865	km./sec. 1.840	km./sec. 1.892	mm. 0.0815	km./sec. 1.740	km./sec. 1.789
4554-626	0.0935	1.978	2.034	0.0942	1.991	2.048	0.0904	1.917	1.972	0.0923	1.954	2.010
4561-591	0.0847	1.801	1.852	0.1009	2.119	2.179	0.0889	1.883	1.937	0.0883	1.871	1.924
4563-939	0.0691	1.491	1.533	0.0859	1.822	1.874	0.0935	1.973	2.029	0.0849	1.803	1.854
4572-156	0.0717	1.539	1.583	0.0880	1.859	1.912	0.0910	1.919	1.974	0.0860	1.819	1.870
4574-396	0.0850	1.800	1.851	0.0916	1.929	1.984	0.1029	2.151	2.212	0.0878	1.853	1.906
Means:		1.738			1.974			2.003			1.892	
Plate:	L512 (1)–(4) June 24, 10.01, E.S.T.			L519 (1)–(4) June 28, 3.55, E.S.T.			L520 (1)–(2) June 28, 4.14, E.S.T.			L522 (1)–(2) June 29, 10.00, E.S.T.		
O'C. on T	$\alpha=0^\circ \beta=6^\circ 9 \gamma=13^\circ 6$ $r=0.973 \epsilon=0.259 \phi=0^\circ 5$ $B_o=2^\circ 2 0.5144v = V$	$\alpha=0^\circ \beta=6^\circ 7 \gamma=12^\circ 3$ $r=0.978 \epsilon=0.260 \phi=0^\circ 5$ $B_o=2^\circ 7 0.5117v = V$	$\alpha=0^\circ \beta=6^\circ 7 \gamma=12^\circ 3$ $r=0.978 \epsilon=0.260 \phi=0^\circ 5$ $B_o=2^\circ 7 0.5117v = V$	$\alpha=0^\circ \beta=6^\circ 7 \gamma=12^\circ 3$ $r=0.978 \epsilon=0.260 \phi=0^\circ 5$ $B_o=2^\circ 7 0.5117v = V$	$\alpha=0^\circ \beta=6^\circ 7 \gamma=12^\circ 3$ $r=0.976 \epsilon=0.260 \phi=0^\circ 6$ $B_o=2^\circ 8 0.5127v = V$							
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
4554-211	mm. 0.0890	km./sec. 1.891	km./sec. 1.945	mm. 0.0849	km./sec. 1.810	km./sec. 1.852	mm. 0.0919	km./sec. 1.947	km./sec. 1.993	mm. 0.0885	km./sec. 1.881	km./sec. 1.929
4554-626	0.0882	1.875	1.929	0.0948	2.004	2.051	0.0842	1.797	1.839	0.0881	1.871	1.919
4561-591	0.0836	1.780	1.831	0.0904	1.915	1.960	0.0944	1.993	2.040	0.0838	1.785	1.830
4563-939	0.0939	1.981	2.030	0.0917	1.937	1.983	0.0797	1.701	1.741	0.0859	1.824	1.870
4572-156	0.0928	1.954	2.010	0.0907	1.913	1.958	0.0863	1.829	1.871	0.0890	1.881	1.929
4574-396	0.0901	1.901	1.956	0.0952	2.002	2.049	0.0954	2.005	2.052	0.0831	1.764	1.809
Means:		1.950			1.976			1.923			1.881	
Plate:	L525 (1)–(2) June 29, 11.30, E.S.T.			L526 (1)–(2) June 30, 9.30, E.S.T.			L527 (1)–(4) July 25, 7.15, E.S.T.			L574 (1)–(4) July 25, 7.40, E.S.T.		
O'C. on T	$\alpha=0^\circ \beta=6^\circ 7 \gamma=12^\circ 8$ $r=0.976 \epsilon=0.260 \phi=0^\circ 6$ $B_o=2^\circ 8 0.5127v = V$	$\alpha=0^\circ \beta=6^\circ 6 \gamma=12^\circ 8$ $r=0.976 \epsilon=0.260 \phi=0^\circ 6$ $B_o=2^\circ 9 0.5127v = V$	$\alpha=0^\circ \beta=4^\circ 9 \gamma=14^\circ 3$ $r=0.973 \epsilon=0.259 \phi=1^\circ 2$ $B_o=5^\circ 3 0.5160v = V$	$\alpha=0^\circ \beta=4^\circ 9 \gamma=14^\circ 3$ $r=0.973 \epsilon=0.259 \phi=1^\circ 2$ $B_o=5^\circ 3 0.5160v = V$	$\alpha=0^\circ \beta=4^\circ 9 \gamma=14^\circ 3$ $r=0.973 \epsilon=0.259 \phi=1^\circ 2$ $B_o=5^\circ 3 0.5160v = V$							
λ	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
4554-211	mm. 0.0870	km./sec. 1.851	km./sec. 1.898	mm. 0.0858	km./sec. 1.826	km./sec. 1.873	mm. 0.0555	km./sec. 1.909	km./sec. 1.970	mm. 0.0556	km./sec. 1.912	km./sec. 1.973
4554-626	0.0913	1.936	1.986	0.0897	1.904	1.952	0.0569	1.953	2.015	0.0537	1.849	1.908
4561-591	0.0885	1.872	1.919	0.0894	1.895	1.944	0.0531	1.828	1.887	0.0530	1.824	1.882
4563-939	0.0884	1.873	1.921	0.0850	1.805	1.851	0.0544	1.870	1.929	0.0576	1.970	2.034
4572-156	0.0932	1.963	2.013	0.0904	1.907	1.956	0.0562	1.922	1.983	0.0544	1.864	1.924
4574-396	0.0910	1.918	1.967	0.0886	1.872	1.920	0.0525	1.798	1.861	0.0510	1.755	1.811
Means:		1.951			1.916			1.941			1.922	

TABLE VII—RESULTS FROM INDIVIDUAL OBSERVATIONS, 6 SPECTRUM LINES—*Concluded*

Plate:	L575 (1)–(4) July 25, 9:35, E.S.T.			L576 (1)–(4) July 25, 9:55, E.S.T.		
	$\alpha=0^\circ$	$\beta=4^\circ 9$	$\gamma=13^\circ 8$	$\alpha=0^\circ$	$\beta=4^\circ 9$	$\gamma=13^\circ 8$
O'C. on T	$r=0.975$	$e=0.260$	$\phi=1^\circ 2$	$r=0.975$	$e=0.260$	$\phi=1^\circ 2$
	$B_o=5^\circ 3$		$0.5149v = V$	$B_o=5^\circ 3$		$0.5149v = V$
λ	d'	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
4554.211	0.0555	1.910	1.967	0.0568	1.951	2.009
4554.626	0.0558	1.917	1.974	0.0540	1.858	1.913
4561.591	0.0532	1.831	1.886	0.0544	1.870	1.925
4563.939	0.0556	1.907	1.963	0.0565	1.936	1.993
4572.156	0.0559	1.912	1.967	0.0581	1.980	2.039
4574.396	0.0554	1.893	1.949	0.0543	1.840	1.915
Means:			1.951			1.966

DISCUSSION OF RESULTS

Mean Velocity.—In Table VIII is given a summary of the mean velocities derived from the measurements of 12 spectrum lines on the 32 observations detailed in Table VI. The summary includes the values for each plate measured violet left and violet right and their means for each of the two observers. In Table IX is a summary of the mean velocities for the 46 additional observations of Table VII, on which O'Connor measured 6 spectrum lines with the plate either violet right or violet left. The values for the individual observations of this latter group are not given in Table VII, where, to save space, only the means of all the observations on each plate are detailed for each spectrum line.

From Table VIII it is evident that there is a systematic difference between the measurements of the plates in the violet left and right positions of about 0.03 km. per sec. for each observer. This, as previously explained, is attributable to the relative motion between the image of the spectrum line and the spider thread of the micrometer, during the time the settings are made, caused by capillary action of the oil between the micrometer thread and nut. Since the rate of this motion is not the same after the micrometer screw has gone into the nut as after it has been screwed in the reverse direction, the mean of the two measurements is not quite the true value of the displacement. Furthermore, the particular method of making the settings of the spectrum line image on the spider thread may introduce irregularities as evident in the settings on plate L569 (4) given above. However, the variety of methods of making the settings in the measurements of these 32 observations reveals the extent of the oil error. As mentioned previously, De Lury measured the first 16 plates in the usual way by making 4 settings on the spectrum line in the middle strip of spectrum followed by 2 settings on the line in each of the outside strips of spectrum; while in the measurements of the second 16 observations, the first settings were made on the middle and outside strips

TABLE VIII—SUMMARY OF MEAN VELOCITIES, 32 OBSERVATIONS, 12 SPECTRUM LINES

Observation		De Lury			O'Connor			De L. and O'C.
		V km./sec.			V km./sec.			
L	1910	(Left)	(Right)	Mean	(Left)	(Right)	Mean	Mean
527 (1)	June 30	1.888	1.863	1.876	1.829	1.818	1.824	1.849
(2)	" 30	1.880	1.841	1.861	1.891	1.836	1.864	1.862
528 (1)	July 5	2.087	2.003	2.045	2.064	1.991	2.028	2.036
(2)	" 5	2.057	2.050	2.054	2.018	1.920	1.969	2.011
531 (1)	" 5	2.067	2.060	2.064	2.025	2.019	2.022	2.043
(2)	" 5	2.072	2.084	2.078	2.052	1.950	2.001	2.040
538 (1)	" 11	1.951	1.905	1.928	1.861	1.848	1.855	1.891
(2)	" 11	1.862	1.863	1.863	1.883	1.883	1.883	1.873
541 (1)	" 11	2.035	1.871	1.953	1.949	1.890	1.920	1.936
(2)	" 11	2.054	2.050	2.052	1.982	1.934	1.958	2.005
544 (1)	" 12	1.915	1.839	1.877	1.952	1.888	1.920	1.899
(2)	" 12	1.991	1.999	1.995	1.975	1.952	1.963	1.979
550 (1)	" 13	2.133	2.071	2.101	2.032	1.992	2.012	2.057
(2)	" 13	2.073	2.001	2.037	1.974	1.950	1.962	2.000
554 (1)	" 13	2.138	2.052	2.095	2.072	2.009	2.041	2.068
(2)	" 13	2.107	2.098	2.103	2.041	2.058	2.050	2.076
558 (1)	" 14	1.976	1.925	1.951	1.969	1.979	1.970	1.960
(2)	" 14	1.954	1.899	1.927	1.963	1.940	1.952	1.939
561 (3)	" 14	1.901	1.864	1.883	1.942	1.949	1.946	1.914
(4)	" 14	2.079	1.998	2.039	2.061	2.023	2.041	2.040
562 (1)	" 14	2.003	2.004	2.004	1.970	1.928	1.949	1.976
(2)	" 14	1.950	1.883	1.917	1.965	1.897	1.931	1.924
565 (3)	" 14	1.997	1.952	1.975	1.960	1.967	1.964	1.969
(4)	" 14	2.013	1.924	1.969	1.883	1.928	1.906	1.937
566 (1)	" 16	1.929	1.869	1.899	1.916	1.926	1.921	1.910
(2)	" 16	1.984	2.063	2.024	2.038	1.934	1.986	2.005
569 (3)	" 16	2.012	1.984	1.998	2.050	2.006	2.028	2.013
(4)	" 16	1.903	1.946	1.925	1.954	1.936	1.945	1.935
570 (1)	" 19	1.817	1.919	1.888	1.873	1.852	1.863	1.865
(2)	" 19	1.794	1.832	1.813	1.884	1.835	1.860	1.836
578 (1)	" 25	1.957	1.954	1.956	1.921	1.955	1.938	1.947
(4)	" 25	1.904	1.930	1.917	1.887	1.906	1.897	1.907
Means:		1.984	1.956	1.970	1.963	1.934	1.949	1.959

on alternate spectrum lines. On the other hand, O'Connor throughout the series set on the line in one outside strip, then on the middle strip followed by settings on the line in the other outside strip. De Lury's settings were made rapidly, usually requiring a little over a minute to complete the 8 settings for each spectrum line, during which time the plate or its image was moving most rapidly relatively to the spider thread. O'Connor's measurements were among his first and were naturally a little more deliberate, requiring usually over two minutes for the set of settings on the three strips, by which time the rate of motion of the plate was considerably reduced. The means of the two groups of 16 observations are as follows:

1st 16 observations, De Lury, 1.998 km./sec., O'Connor, 1.955 km./sec.
 2nd 16 " " 1.942 " " 1.945 "

Since the method employed by De Lury in the second group insured the elimination of the systematic error in the mean, and since the two measures practically agree for this group, it may be supposed that O'Connor's measurements in the mean of the whole group are practically free from this systematic error, and also that the difference between the two in the first group is mainly due to the effect of the systematic oil error in De Lury's measurements. Consequently it would seem that the mean, 1.959 km. per sec., of all the measurements of the 32 observations should be corrected to 1.950 km. per sec.

TABLE IX—SUMMARY OF MEAN VELOCITIES, 46 OBSERVATIONS, 6 SPECTRUM LINES

Observation			O'Connor		Observation			O'Connor	
			V km./sec.					V km./sec.	
L	1910		(Left)	(Right)	L	1910		(Left)	(Right)
493 (1)	June	21	.....	2.033	520 (2)	June	28	1.927	
(2)	"	21	.....	1.983	522 (1)	"	29	1.834	
497 (1)	"	21	.....	1.886	(2)	"	29	1.929	
(2)	"	21	.....	1.843	525 (1)	"	29	.....	1.960
502 (1)	"	23	1.892	.....	(2)	"	29	.....	1.942
(2)	"	23	1.844	.....	526 (1)	"	30	1.888	
505 (1)	"	23	.....	1.887	(2)	"	30	1.943	
508 (3)	"	23	1.738	.....	573 (1)	July	25	1.931	
509 (1)	"	23	.....	1.974	(2)	"	25	1.905	
510 (1)	"	23	2.003	.....	(3)	"	25	1.898	
511 (1)	"	24	.....	1.975	(4)	"	25	2.029	
(2)	"	24	.....	1.975	574 (1)	"	25	.....	1.874
(3)	"	24	.....	1.788	(2)	"	25	.....	1.989
(4)	"	24	.....	1.930	(3)	"	25	.....	1.875
512 (1)	"	24	1.953	.....	(4)	"	25	.....	1.950
(2)	"	24	1.909	.....	575 (1)	"	25	2.038	
(3)	"	24	1.935	.....	(2)	"	25	1.929	
(4)	"	24	2.009	.....	(3)	"	25	1.972	
519 (1)	"	28	.....	2.003	(4)	"	25	1.866	
(2)	"	28	.....	2.012	576 (1)	"	25	1.944	
(3)	"	28	.....	1.890	(2)	"	25	1.949	
(4)	"	28	.....	1.997	(3)	"	25	1.973	
520 (1)	"	28	1.919	.....	(4)	"	25	1.998	
Means:								1.929	1.933

The mean of the additional group of 46 observations, derived from Table IX, is 1.931 km. per sec. The mean of the whole series of 78 observations is $1.943 \pm .005$ km. per sec.; and it would seem that this mean should be corrected to about 1.940 km. per sec. as representing the equatorial velocity of the solar rotation in the $\lambda 4500$ region of the spectrum from June 21 to July 25.

The Bearing of the Results on the Question of Variation of the Rotational Velocity with Elevation in the Solar Atmosphere.—The spectrum lines measured in the present series of observations were selected, as previously explained, in order to throw more light on the interesting and important findings of Dr. Walter S. Adams at Mount Wilson Observatory concerning the increase of rotational velocity with elevation in the sun's atmosphere.

Six lines having large penumbral displacements in sunspot spectra were chosen as representing the lower levels and six with small or negative displacements representing the higher levels, giving about the maximum range in elevation of the elements producing easily measurable spectrum lines in the $\lambda 4500$ region. Later, reliable chromospheric elevations were published by Mitchell, for all but one of the selected lines. The elevation of this line may be inferred from its penumbral displacement. The mean velocity for each spectrum line from the four measurements of each of the 32 observations, two by each observer, is given in Table X, along with groupings as to elevation and as to strengthening in the flash spectrum. In Table XI similar means are given for the measurements of six lines on the additional 46 observations.

TABLE X—SUMMARY OF THE MEAN VALUES OF THE EQUATORIAL VELOCITY OF ROTATION FOR 12 SPECTRUM LINES, 32 OBSERVATIONS

Sun				Chromosphere		Sunspot			Rotational velocity					
λ Rowland	λ I.A.	Element	Int.	Int.	Height	Int.	Penumbral displacement	Mean	Heights		Strength in flash			
				km.					High	Low	Strong	Weak		
\AA							\AA	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.		
4376.942	.784	Fe-Cr	1	1d	400	2	0.026	1.76	1.970	.....	1.970	.....	1.970
4379.927	.771	Zr ⁺ Cr	0	2	400	1	0.029	2.01	1.956	.....	.....	1.956	.....
4383.720s	.559	Fe	15	15	1600	15	-0.013	-0.91	1.925	1.925	.....	.....	1.925
4404.927s	.763	Fe	10	12	1200	10	-0.004	-0.30	1.988	1.988	.....	1.988	.....
4415.293	.137	Fe	8	8	800	8	-0.003	-0.22	1.952	1.952	.....	.....	1.952
4416.636	.477	V	0	1	350	3	0.035	2.35	1.939	.....	1.939	1.939	.....
4554.211s	.038	Ba ⁺	8	50	2000	10	0.004	0.24	1.954	1.954	.....	1.954	.....
4554.626	.462	Fe	1	—	(400)	2	0.025	1.65	1.983	.....	1.983	.....	.....
4561.591	.419	—	1	0	350	1	0.023	1.53	1.969	.....	1.969	.....	1.969
4563.939s	.768	Ti ⁺	4	30	2500	3	0.005	0.32	1.970	1.970	.....	1.970	.....
4572.156s	1.982	Ti ⁺	6	35	2500	4	0.006	0.38	1.956	1.956	.....	1.956	.....
4574.396	.227	Fe	1	0	350	1	0.029	1.90	1.952	.....	1.952	.....	1.952
Means:									1.959	1.957	1.961	1.961	1.954	

From Table X, it is seen that 6 spectrum lines of average chromospheric elevation, 1,767 km., and average penumbral displacement, -0.001 \AA or $-0.008 \text{ km. per sec.}$, yield a mean velocity of rotation of $1.957 \text{ km. per sec.}$; while the other 6 lines, average elevation, 375 km., and average penumbral displacement, 0.028 \AA or $1.87 \text{ km. per sec.}$, have a mean rotational velocity of $1.961 \text{ km. per sec.}$. Thus for a difference in elevation of 1,400 km. no appreciable difference in the velocity of rotation is indicated from the present series of observations.

From Table XI, 3 spectrum lines of average elevation, 2333 km., and average penumbral displacement, 0.005 \AA or $0.31 \text{ km. per sec.}$, show a mean velocity of rotation of $1.923 \text{ km. per sec.}$; while the other 3 lines, average elevation, 367 km., and average penumbral displacement, 0.026 \AA or $1.69 \text{ km. per sec.}$, indicate a mean rotational velocity of $1.939 \text{ km. per sec.}$. Thus for this group of 46 observations, an average difference of elevation of 1,966 km. is accompanied by a difference in rotational velocity of $0.016 \text{ km. per sec.}$, with the higher velocity at the lower level. Coupling these results

with those for the same 6 spectrum lines in Table X, the resulting mean velocities for the 78 observations yield means of 1.939 and 1.951 km. per sec. respectively for the higher and lower levels, with a difference of 0.013 km. per sec. Thus the results are at variance with the findings at Mount Wilson Observatory that increased rotational velocity accompanies increase in elevation in the solar atmosphere.

TABLE XI—SUMMARY OF THE MEAN VALUES OF THE EQUATORIAL VELOCITY OF ROTATION FOR 6 SPECTRUM LINES, 46 OBSERVATIONS

Sun				Chromosphere		Sunspot			Rotational velocity				
λ Rowland	λ I.A.	Element	Int.	Int.	Height	Int.	Penumbral displacement	Mean	Heights		Strength in flash		
					km.				High	Low	Strong	Weak	
Å					km.	Å	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	
4554.211s	.038	Ba ⁺	8	50	2000	10	0.004	0.24	1.907	1.907	.....	1.907	
4554.626	.462	Fe	1	—	(400)	2	0.025	1.65	1.968	.....	1.968	.....
4561.591	.419	—	1	0	350	1	0.023	1.53	1.932	.....	1.932	.....	1.932
4563.939s	.768	Ti ⁺	4	30	2500	3	0.005	0.32	1.921	1.921	.....	1.921	
4572.156s	1.982	Ti ⁺	6	35	2500	4	0.006	0.38	1.940	1.940	.....	1.940	
4574.396	.227	Fe	1	0	350	1	0.029	1.90	1.917	.....	1.917	.....	1.917
Means:								1.931	1.923	1.938	1.923	1.925	

In view of the fact that in the green and yellow green region of the spectrum higher velocities have been found for spectrum lines not greatly weakened at the limb of the sun relatively to the centre of the solar disc than for lines considerably weakened at the limb, in amounts varying with terrestrial haziness, it was considered advisable to group, in Table X, the velocities of the various spectrum lines in accordance with their strengthening or not in the flash spectrum. Six strengthened lines exhibit a mean rotational velocity of 1.961 km. per sec., and five unstrengthened lines yield a mean velocity of 1.954 km. per sec. The difference, 0.007 km. per sec., is too small to be regarded as significant; while the corresponding difference for the 5 lines of Table XI whose chromospheric intensities are known is still smaller, namely 0.002 km. per sec.

SOLAR ROTATION

SECTION 3—DETERMINATIONS OF THE EQUATORIAL VELOCITY FROM OBSERVATIONS AT $\lambda 5600$ IN 1910

BY

RALPH E. DE LURY

The region of the spectrum from $\lambda 5500$ to $\lambda 5700$ for the observation of the solar rotation was assigned to the Dominion Observatory at the 1910 meeting¹ of the International Union for Co-operation in Solar Research. This part of the spectrum is not of particular interest: the range in intensity of the spectrum lines is small; the difference in elevation in the solar atmosphere of the materials producing the spectrum lines is very small for lines of sufficient intensity for easy measurement in the limb spectrum; not many elements are represented among the lines suitable for rotation measurements; and few lines of ionized elements are present. However, it was desirable that this region of the spectrum be represented in the co-operative attack on the problem of the solar rotation, and since the initiation of the program a goodly number of observations have been made yearly. While lines due to the terrestrial atmosphere are present in this part of the spectrum, they are scarcely intense enough to serve for accurate measurement of observational or mensurational errors in the determinations of the rotational displacements of the solar spectrum lines; but, from 1913 on, some of the advantages of the terrestrial lines were provided by strips of iodine absorption spectrum. The yellow-green region of the spectrum is probably relatively sensitive to the influence of general sunlight from terrestrial haze in depressing the measured values of the solar rotation, since water droplets and cirrus ice crystals selectively reflect or transmit green light. Evidence of such an influence in lessening the values of the solar rotation will be shown in the following discussion of the preliminary observations at $\lambda 5600$ made in November and December, 1910.

Observations.—Using the same equipment as employed in making the observations at $\lambda 4500$, discussed in the preceding Section, the same observers obtained about 150 spectrograms recording the rotational line-displacements in spectra from opposite points within the solar limb at various latitudes from the equator to the pole. The record of 68 of these observations, made at the equator, is given in Table XII.

Measurements.—Early measurements² of some of the observations at $\lambda 5600$, like those at $\lambda 4500$ already referred to, exhibited serious systematic errors. Having finally detected the systematic errors of measurement caused by the micrometer oil, the writer returned to the measurement of these early observations. A group of 32 observations of the equatorial velocity, L609 (1)-L629 (1), were chosen, and the 10 spectrum lines given in the first group of Table XIII were selected for measurement (see Figure 1).

¹ Trans. Int. Union for Solar Res., Vol. III, p. 83.

² Rept. Chief Astronomer, 1911, 129 and 264.

To eliminate the systematic error, the split nut of the micrometer was tightened, and the lines were alternately measured commencing with the central strip of spectrum (east limb) or the outside strips of spectrum (west limb). Thus, by reversing the order of the alternations on every other observation, the mean value for each observation and the means for each line in the whole series of observations are freed from the systematic error of measurement. The results are given in Table XIV, where, as in the previous Sections, d' denotes the measured displacement, plate violet left, and d'' , plate violet right. Since in many later observations 6 lines (the second group in Table XIII) were measured, and their behaviour known in blended spectra of limb and haze or limb and centre of the solar disc, the 32 observations were re-measured using these 6 lines, and in addition the 36 other equatorial observations of less uniform quality were measured with plate either left or right. The results of these measurements are given in Table XV.

TABLE XII—RECORD OF OBSERVATIONS OF THE SOLAR ROTATION, $\lambda 5600$

Plate	1910		Position			Slit width	Exposure	Observing conditions and remarks		
	Date	E.S.T.	α	Disc	r			D	B	
L		h. m.	°	mm.		mm.	sec.			Exposures:
600 (1)–(5)	Nov. 9	3 20	0	223.0	0.950	0.025	15–50	Fair	Fair	15, 20, 30, 40, 50 sec.
601 (1)–(6)	" 9	3 37	0	233.0	0.950	0.025	20–32			20, 20, 25, 25, 32, 30 sec.
602 (1)–(6)	" 9	3 50	0	233.0	0.950	0.025	25–50			25, 35, 45, 30, 40, 50 sec.
603 (1)–(5)	" 27	2 03	0	233.5	0.948	0.025	30–60			30, 35, 40, 45, 60 sec.
606 (1)–(4)	Dec. 5	2 30	0.3	233.8	0.947	0.025	25–50			25, 30, 40, 50 sec.
607 (1)–(5)	" 5	2 40	0.3	233.8	0.947	0.025	30–60			30, 35, 40, 60, 50 sec.
608 (1)–(5)	" 6	1 25	0	234.5	0.946	0.025	20–40			20, 30, 25, 35, 40 sec.
609 (1), (2)	" 6	1 45	0	234.5	0.946	0.025	30	Fair	Fair	Steady clock driving
610 (4), (5)	" 6	1 55	0	234.5	0.946	0.025	30			
611 (1), (2)	" 6	2 50	0	233.0	0.952	0.025	40			
613 (1), (6)	" 8	1 20	0	234.8	0.945	0.025	40			
614 (1), (2)	" 8	1 38	0	235.2	0.943	0.025	40			
614a (1)	" 8	2 02	0	235.0	0.944	0.025	45			
616 (1), (2)	" 9	12 42	0	236.0	0.940	0.025	35			
617 (1), (2)	" 9	12 52	0	236.0	0.940	0.025	35			
618 (1), (2)	" 9	1 12	0	236.0	0.940	0.025	35			
619 (1), (2)	" 9	1 20	0	236.0	0.940	0.025	35			
622 (1), (2)	" 10	12 32	0	235.3	0.943	0.025	35			
623 (1), (2)	" 10	12 42	0	236.0	0.940	0.025	35			
624 (1), (2)	" 10	1 02	0	236.0	0.940	0.025	35			
625 (1)	" 10	1 10	0	236.0	0.940	0.025	35			
627 (1), (2)	" 12	1 02	0	236.0	0.939	0.025	30			
628 (1), (2)	" 12	1 08	0	236.0	0.939	0.025	30			
629 (1)	" 12	1 40	0	236.0	0.939	0.025	60	Fair		

(1) Unsteady

TABLE XIII—THE SPECTRUM LINES MEASURED AND THEIR VELOCITY FACTORS, F , FOR
1 mm. DISPLACEMENT

Rowland	I.A.	Element	Intensity			Height	Scale	F
			Disc	Spot	Flash			
Å						km.	Å/mm.	km./sec.
5528-641s	.420	Mg	8	8	8	400	0.9494	51.49
5535-061s	4.849	Fe ⁺	2	0	15	600	0.9488	51.40
5562-933	.718	Fe	2	1	2	350	0.9477	51.08
5569-848s	.633	Fe	6	7	7	600	0.9476	51.02
5576-320s	.101	Fe	4	4	6	500	0.9468	50.91
5578-946	.731	Ni	1	2	4	500	0.9466	50.88
5586-991	.773	Fe	7	8	8	600	0.9460	50.77
5588-985s	.766	Ca	6	10	6	600	0.9458	50.74
5590-343s	.128	Ca	3	7	1	400	0.9457	50.73
5593-961	.748	Ni	0	-1	1d	400	0.9455	50.68
5586-991	.773	Fe	7	8	8	600		
5587-800	.583	Fe	0	0	1	300		
5588-084	7.870	Ni	1	2	4	400	0.9459	50.76
5588-985s	.766	Ca	6	10	6	600		
5589-582	.368	Ni	0	0	1	300		
5590-343s °	.128	Ca	3	7	1	400		

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES

Plate	L609 (1) Dec. 6, 1:45, E.S.T.							L609 (2) Dec. 6, 1:46, E.S.T.						
De L. on T	$\alpha=0^\circ$ $\beta=7^\circ 2'$ $\gamma=18^\circ 9'$ $r=0.946$ $\epsilon=0.267$ $\phi=0^\circ 0'$ $B_0=0^\circ 1'$ $0.5285v = V$							$\alpha=0^\circ$ $\beta=7^\circ 2'$ $\gamma=18^\circ 9'$ $r=0.946$ $\epsilon=0.267$ $\phi=0^\circ 0'$ $B_0=0^\circ 1'$ $0.5285v = V$						
	λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	
		mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	
5528-641	0.0631	1.759	1.859	0.0635	1.769	1.870	0.0608	1.700	1.797	0.0650	1.808	1.911		
5535-061	0.0695	1.920	2.029	0.0685	1.894	2.002	0.0732	2.015	1.130	0.0714	1.969	2.081		
5562-933	0.0637	1.761	1.861	0.0641	1.771	1.872	0.0640	1.769	1.870	0.0645	1.781	1.883		
5569-848	0.0673	1.851	1.957	0.0681	1.871	1.978	0.0631	1.744	1.843	0.0703	1.927	2.037		
5576-320	0.0637	1.758	1.856	0.0651	1.791	1.893	0.0663	1.822	1.926	0.0652	1.794	1.896		
5578-946	0.0657	1.805	1.908	0.0700	1.915	2.024	0.0645	1.775	1.876	0.0657	1.805	1.908		
5586-991	0.0642	1.764	1.865	0.0655	1.797	1.899	0.0656	1.800	1.903	0.0676	1.850	1.955		
5588-985	0.0692	1.890	1.998	0.0667	1.826	1.930	0.0705	1.923	2.033	0.0673	1.841	1.946		
5590-343	0.0692	1.889	1.997	0.0683	1.866	1.972	0.0671	1.836	1.941	0.0679	1.856	1.962		
5593-961	0.0711	1.936	2.046	0.0625	1.718	1.816	0.0724	1.969	2.081	0.0684	1.867	1.973		
Means:			1.938			1.926			1.940			1.955		
							1.932						1.948	

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES—Continued

Plate:	L610 (4) Dec. 6, 1:55, E.S.T.						L610 (5) Dec. 6, 1:56, E.S.T.					
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=18^\circ 9'$ $r=0.946 \epsilon=0.267 \phi=0^\circ 0'$ $B_o=0^\circ 1' 0.5285v = V$						$\alpha=0^\circ \beta=7^\circ 2' \gamma=18^\circ 9'$ $r=0.946 \epsilon=0.267 \phi=0^\circ 0'$ $B_o=0^\circ 1' 0.5285v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528.641	0.0695	1.924	2.034	0.0700	1.937	2.047	0.0686	1.900	2.008	0.0750	2.065	2.183
5535.061	0.0679	1.879	1.986	0.0724	1.995	2.109	0.0703	1.941	2.052	0.0730	2.010	2.125
5562.933	0.0695	1.909	2.018	0.0743	2.032	2.148	0.0657	1.812	1.915	0.0634	1.753	1.853
5569.848	0.0685	1.881	1.988	0.0687	1.887	1.995	0.0641	1.769	1.870	0.0655	1.805	1.908
5576.320	0.0684	1.875	1.982	0.0649	1.786	1.888	0.0694	1.901	2.009	0.0690	1.891	1.999
5578.946	0.0716	1.956	2.067	0.0685	1.877	1.984	0.0680	1.864	1.970	0.0648	1.783	1.885
5586.991	0.0655	1.797	1.899	0.0675	1.848	1.953	0.0657	1.802	1.905	0.0678	1.855	1.961
5588.985	0.0677	1.852	1.958	0.0681	1.862	1.968	0.0656	1.798	1.900	0.0648	1.778	1.879
5590.343	0.0642	1.762	1.862	0.0602	1.661	1.756	0.0705	1.922	2.032	0.0643	1.765	1.866
5593.961	0.0682	1.862	1.968	0.0699	1.905	2.014	0.0691	1.885	1.992	0.0697	1.900	2.008
Means:		1.976			1.986			1.965			1.967	
					1.981						1.966	
Plate:	L611 (1) Dec. 6, 2:48, E.S.T.						L611 (2) Dec. 6, 2:49, E.S.T.					
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=17^\circ 8'$ $r=0.952 \epsilon=0.269 \phi=0^\circ 0'$ $B_o=0^\circ 1' 0.5251v = V$						$\alpha=0^\circ \beta=7^\circ 2' \gamma=17^\circ 8'$ $r=0.952 \epsilon=0.269 \phi=0^\circ 0'$ $B_o=0^\circ 1' 0.5251v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528.641	0.0529	1.497	1.572	0.0608	1.701	1.787	0.0675	1.873	1.967	0.0709	1.961	2.060
5535.061	0.0715	1.973	2.072	0.0644	1.790	1.880	0.0704	1.944	2.042	0.0744	2.047	2.150
5562.933	0.0699	1.920	2.017	0.0714	1.959	2.058	0.0708	1.943	2.041	0.0705	1.936	2.033
5569.848	0.0667	1.837	1.920	0.0707	1.939	2.037	0.0692	1.900	1.996	0.0708	1.941	2.039
5576.320	0.0645	1.777	1.866	0.0690	1.892	1.987	0.0674	1.851	1.944	0.0675	1.854	1.947
5578.946	0.0712	1.946	2.044	0.0684	1.875	1.969	0.0722	1.972	2.071	0.0702	1.921	2.018
5586.991	0.0655	1.798	1.888	0.0642	1.765	1.854	0.0687	1.879	1.974	0.0744	2.024	2.126
5588.985	0.0677	1.853	1.946	0.0739	2.010	2.111	0.0658	1.804	1.895	0.0679	1.858	1.951
5590.343	0.0677	1.852	1.945	0.0697	1.903	1.999	0.0662	1.814	1.905	0.0720	1.961	2.060
5593.961	0.0690	1.883	1.978	0.0698	1.904	2.000	0.0693	1.891	1.986	0.0649	1.780	1.870
Means:		1.925			1.968			1.982			2.025	
					1.947						2.004	

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES—Continued

Plate:	L613 (1) Dec. 8, 1:18, E.S.T.						L613 (2) Dec. 8, 1:22, E.S.T.					
	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 1'$ $r=0.945 \epsilon=0.267 \phi=0^\circ 0'$ $B_o=-0.2 \quad 0.5291v = V$						$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 1'$ $r=0.945 \epsilon=0.267 \phi=0^\circ 0'$ $B_o=-0.2 \quad 0.5291v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528·641	0.0625	1.743	1.845	0.0733	2.023	2.141	0.0643	1.790	1.894	0.0615	1.718	1.818
5535·061	0.0699	1.930	2.043	0.0665	1.843	1.950	0.0676	1.871	1.980	0.0703	1.941	2.054
5562·933	0.0704	1.932	2.045	0.0704	1.932	2.045	0.0675	1.858	1.966	0.0630	1.743	1.845
5569·848	0.0684	1.879	1.989	0.0727	1.989	2.105	0.0705	1.932	2.045	0.0689	1.892	1.002
5576·320	0.0757	2.061	2.181	0.0678	1.860	1.968	0.0584	1.621	1.716	0.0511	1.435	1.519
5578·946	0.0696	1.905	2.016	0.0695	1.902	2.013	0.0726	1.981	2.096	0.0676	1.854	1.962
5586·991	0.0672	1.840	1.947	0.0688	1.881	1.991	0.0654	1.795	1.900	0.0660	1.810	1.916
5588·985	0.0725	1.973	2.088	0.0724	1.971	2.086	0.0648	1.778	1.882	0.0635	1.745	1.847
5590·343	0.0683	1.866	1.975	0.0697	1.902	2.013	0.0647	1.775	1.878	0.0577	1.597	1.690
5593·961	0.0708	1.928	2.040	0.0632	1.735	1.836	0.0726	1.974	2.089	0.0734	1.994	2.110
Means:		2.017			2.015			1.945			1.876	
						2.016					1.911	
Plate:	L614 (1) Dec. 8, 1:38, E.S.T.						L614 (2) Dec. 8, 1:39, E.S.T.					
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 4'$ $r=0.943 \epsilon=0.267 \phi=0^\circ 0'$ $B_o=-0.2 \quad 0.5301v = V$						$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 4'$ $r=0.943 \epsilon=0.267 \phi=0^\circ 0'$ $B_o=-0.2 \quad 0.5301v = V$					
	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528·641	0.0743	2.046	2.169	0.0740	2.039	2.162	0.0684	1.894	2.008	0.0697	1.928	2.044
5535·061	0.0669	1.852	1.963	0.0669	1.852	1.963	0.0574	1.608	1.705	0.0598	1.670	1.771
5562·933	0.0653	1.801	1.909	0.0703	1.928	2.044	0.0647	1.785	1.892	0.0653	1.801	1.909
5569·848	0.0689	1.891	2.005	0.0571	1.590	1.686	0.0649	1.789	1.897	0.0707	1.937	2.054
5576·320	0.0688	1.885	1.998	0.0683	1.872	1.985	0.0640	1.762	1.868	0.0672	1.844	1.955
5578·946	0.0659	1.809	1.918	0.0681	1.865	1.977	0.0571	1.586	1.681	0.0714	1.949	2.066
5586·991	0.0657	1.801	1.909	0.0665	1.821	1.931	0.0614	1.692	1.794	0.0674	1.844	1.955
5588·985	0.0656	1.797	1.905	0.0631	1.734	1.838	0.0710	1.934	2.050	0.0675	1.871	1.984
5590·343	0.0672	1.837	1.948	0.0645	1.769	1.875	0.0630	1.731	1.835	0.0650	1.781	1.888
5593·961	0.0674	1.841	1.952	0.0618	1.699	1.801	0.0689	1.879	1.992	0.0651	1.783	1.890
Means:		1.968			1.926			1.872			1.952	
					1.947						1.912	

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES—Continued

Plate:	L614a (1) Dec. 8, 2:02, E.S.T.						L615 (1) Dec. 8, 2:15, E.S.T.					
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 3'$ $r=0.944 \epsilon=0.267 \phi=0^\circ 0'$ $B_o=-0^\circ 2' 0.5298v = V$						$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 1'$ $r=0.945 \epsilon=0.267 \phi=0^\circ 0'$ $B_o=-0^\circ 2' 0.5291v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528-641	0.0654	1.817	1.925	0.0645	1.794	1.901	0.0744	2.050	2.170	0.0766	2.106	2.229
5535-061	0.0764	2.096	2.221	0.0678	1.875	1.987	0.0729	2.008	2.125	0.0738	2.031	2.149
5562-933	0.0626	1.732	1.835	0.0628	1.737	1.841	0.0691	1.899	2.010	0.0675	1.858	1.966
5569-848	0.0632	1.745	1.849	0.0670	1.842	1.952	0.0668	1.838	1.945	0.0698	1.915	2.027
5576-320	0.0781	2.119	2.245	0.0736	2.007	2.127	0.0705	1.929	2.041	0.0687	1.883	1.993
5578-946	0.0741	2.018	2.138	0.0791	2.145	2.273	0.0656	1.803	1.908	0.0632	1.742	1.844
5586-991	0.0624	1.717	1.819	0.0701	1.913	2.027	0.0638	1.754	1.856	0.0661	1.812	1.918
5588-985	0.0654	1.792	1.899	0.0726	1.975	2.093	0.0697	1.902	2.013	0.0694	1.895	2.005
5590-343	0.0631	1.733	1.836	0.0644	1.766	1.871	0.0704	1.919	2.031	0.0705	1.922	2.034
5593-961	0.0645	1.767	1.872	0.0594	1.638	1.736	0.0749	2.033	2.152	0.0683	1.865	1.974
Means:			1.964			1.981			2.025			2.014
						1.973						2.020
Plate:	L616 (1) Dec. 9, 12:42, E.S.T.						L616 (2) Dec. 9, 12:43, E.S.T.					
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 9'$ $r=0.940 \epsilon=0.266 \phi=0^\circ 1'$ $B_o=-0^\circ 3' 0.5318v = V$						$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 9'$ $r=0.940 \epsilon=0.266 \phi=0^\circ 1'$ $B_o=-0^\circ 3' 0.5318v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528-641	0.0618	1.724	1.833	0.0610	1.704	1.812	0.0694	1.920	2.042	0.0644	1.791	1.905
5535-061	0.0624	1.737	1.847	0.0618	1.721	1.830	0.0592	1.654	1.759	0.0633	1.760	1.872
5562-933	0.0604	1.676	1.782	0.0581	1.617	1.720	0.0593	1.648	1.753	0.0616	1.706	1.814
5569-848	0.0636	1.755	1.866	0.0621	1.717	1.826	0.0585	1.625	1.728	0.0668	1.837	1.954
5576-320	0.0614	1.696	1.804	0.0607	1.678	1.785	0.0649	1.785	1.898	0.0658	1.788	1.902
5578-946	0.0638	1.756	1.868	0.0632	1.741	1.852	0.0680	1.863	1.981	0.0705	1.927	2.049
5586-991	0.0679	1.857	1.975	0.0671	1.837	1.954	0.0628	1.727	1.837	0.0634	1.743	1.854
5588-985	0.0679	1.856	1.974	0.0693	1.891	2.011	0.0702	1.914	2.036	0.0663	1.815	1.930
5590-343	0.0672	1.837	1.954	0.0629	1.728	1.838	0.0680	1.857	1.975	0.0675	1.845	1.962
5593-961	0.0657	1.798	1.912	0.0717	1.950	2.074	0.0743	2.016	2.144	0.0708	1.927	2.049
Means:			1.882			1.870			1.915			1.929
						1.876						1.922

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES—Continued

Plate:	L617 (1) Dec. 9, 12:52, E.S.T.							L617 (2) Dec. 9, 12:53, E.S.T.						
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 9'$ $r=0.940 \epsilon=0.266 \phi=0^\circ 1'$ $B_0=-0^\circ 3' 0.5318v = V$							$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 9'$ $r=0.940 \epsilon=0.266 \phi=0^\circ 1'$ $B_0=-0^\circ 3' 0.5318v = V$						
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V		
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.		
5528-641	0.0646	1.796	1.910	0.0661	1.835	1.952	0.0633	1.763	1.875	0.0642	1.786	1.899		
5535-061	0.0600	1.675	1.781	0.0570	1.598	1.699	0.0658	1.824	1.940	0.0654	1.814	1.929		
5562-933	0.0612	1.696	1.804	0.0678	1.865	1.983	0.0602	1.671	1.777	0.0661	1.821	1.937		
5569-848	0.0687	1.886	2.006	0.0683	1.875	1.994	0.0646	1.781	1.894	0.0644	1.776	1.889		
5576-320	0.0646	1.778	1.891	0.0657	1.806	1.921	0.0692	1.895	2.015	0.0660	1.813	1.928		
5578-946	0.0606	1.675	1.781	0.0613	1.692	1.799	0.0627	1.728	1.838	0.0625	1.723	1.832		
5586-991	0.0654	1.794	1.908	0.0626	1.722	1.831	0.0655	1.796	1.910	0.0673	1.842	1.959		
5588-985	0.0622	1.711	1.820	0.0653	1.802	1.916	0.0676	1.848	1.965	0.0625	1.719	1.828		
5590-343	0.0661	1.809	1.924	0.0666	1.822	1.938	0.0659	1.804	1.919	0.0608	1.675	1.781		
5593-961	0.0598	1.648	1.753	0.0617	1.696	1.804	0.0742	2.013	2.141	0.0741	2.011	2.139		
Means:		1.858			1.884			1.927				1.912		
							1.871					1.920		
Plate:	L618 (1) Dec. 9, 1:12, E.S.T.							L618 (2) Dec. 9, 1:14, E.S.T.						
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 9'$ $r=0.940 \epsilon=0.266 \phi=0^\circ 1'$ $B_0=-0^\circ 3' 0.5318v = V$							$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 9'$ $r=0.940 \epsilon=0.266 \phi=0^\circ 1'$ $B_0=-0^\circ 3' 0.5318v = V$						
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V		
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.		
5528-641	0.0613	1.711	1.820	0.0620	1.730	1.840	0.0614	1.714	1.823	0.0613	1.711	1.820		
5535-061	0.0693	1.914	2.036	0.0654	1.814	1.929	0.0725	1.996	2.123	0.0685	1.893	2.013		
5562-933	0.0587	1.632	1.736	0.0663	1.826	1.942	0.0643	1.775	1.888	0.0590	1.640	1.744		
5569-848	0.0635	1.753	1.864	0.0644	1.776	1.889	0.0643	1.773	1.886	0.0670	1.842	1.959		
5576-320	0.0643	1.770	1.882	0.0660	1.813	1.928	0.0599	1.658	1.763	0.0614	1.696	1.804		
5578-946	0.0730	1.990	2.116	0.0640	1.761	1.873	0.0659	1.809	1.924	0.0635	1.748	1.859		
5586-991	0.0662	1.814	1.929	0.0660	1.809	1.924	0.0648	1.778	1.891	0.0667	1.827	1.943		
5588-985	0.0666	1.823	1.939	0.0663	1.815	1.930	0.0671	1.835	1.952	0.0672	1.838	1.955		
5590-343	0.0724	1.969	2.094	0.0659	1.804	1.919	0.0650	1.781	1.894	0.0615	1.693	1.801		
5593-961	0.0619	1.702	1.810	0.0611	1.681	1.788	0.0707	1.925	2.047	0.0633	1.737	1.847		
Means:		1.923			1.896			1.919				1.875		
					1.910							1.897		

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES—Continued

Plate:	L619 (1) Dec. 9, 1:20, E.S.T.						L620 (1) Dec. 9, 1:35, E.S.T.					
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 9'$ $r=0.940 \epsilon=0.266 \phi=0^\circ 1'$ $B_0=-0^\circ 3' 0.5318v =V$						$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 4'$ $r=0.943 \epsilon=0.267 \phi=0^\circ 1'$ $B_0=-0^\circ 3' 0.5301v =V$					
	λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$
		mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.
5528-641	0.0661	1.835	1.952	0.0701	1.938	2.061	0.0609	1.702	1.804	0.0650	1.808	1.917
5535-061	0.0697	1.924	2.046	0.0633	1.760	1.872	0.0609	1.699	1.801	0.0656	1.820	1.930
5562-933	0.0586	1.885	2.005	0.0618	1.711	1.820	0.0628	1.738	1.843	0.0656	1.809	1.918
5569-848	0.0622	1.720	1.829	0.0651	1.794	1.908	0.0613	1.698	1.800	0.0626	1.731	1.835
5576-320	0.0667	1.831	1.947	0.0621	1.714	1.823	0.0668	1.835	1.945	0.0683	1.873	1.986
5578-946	0.0646	1.776	1.889	0.0669	1.835	1.952	0.0522	1.462	1.555	0.0649	1.785	1.892
5586-991	0.0592	1.636	1.740	0.0608	1.677	1.783	0.0631	1.736	1.841	0.0617	1.701	1.803
5588-985	0.0648	1.777	1.890	0.0658	1.802	1.916	0.0635	1.745	1.850	0.0590	1.631	1.729
5590-343	0.0653	1.789	1.903	0.0661	1.809	1.924	0.0691	1.886	2.000	0.0673	1.841	1.952
5593-961	0.0546	1.770	1.882	0.0662	1.709	1.818	0.0612	1.685	1.786	0.0585	1.616	1.713
Means:			1.908			1.888			1.823			1.868
						1.898						1.846
Plate:	L622 (1) Dec. 10, 12:32, E.S.T.						L622 (2) Dec. 10, 12:33, E.S.T.					
De L. on T	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 4'$ $r=0.943 \epsilon=0.267 \phi=0^\circ 1'$ $B_0=-0^\circ 4' 0.5301v =V$						$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 4'$ $r=0.943 \epsilon=0.267 \phi=0^\circ 1'$ $B_0=-0^\circ 4' 0.5301v =V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528-641	0.0696	1.926	2.042	0.0705	1.949	2.066	0.0669	1.857	1.969	0.0659	1.831	1.941
5535-061	0.0651	1.807	1.916	0.0634	1.763	1.869	0.0659	1.828	1.938	0.0665	1.843	1.954
5562-933	0.0711	1.950	2.067	0.0711	1.950	2.067	0.0643	1.776	1.883	0.0663	1.827	1.937
5569-848	0.0682	1.874	1.987	0.0674	1.853	1.965	0.0662	1.823	1.933	0.0663	1.825	1.935
5576-320	0.0705	1.929	2.045	0.0693	1.898	2.012	0.0658	1.809	1.918	0.0667	1.832	1.942
5578-946	0.0653	1.795	1.903	0.0631	1.739	1.844	0.0654	1.798	1.906	0.0708	1.935	2.051
5586-991	0.0688	1.881	1.994	0.0680	1.861	1.973	0.0647	1.777	1.884	0.0631	1.736	1.841
5588-985	0.0675	1.846	1.957	0.0683	1.867	1.979	0.0660	1.808	1.917	0.0642	1.763	1.869
5590-343	0.0669	1.831	1.941	0.0683	1.866	1.978	0.0645	1.770	1.877	0.0653	1.790	1.898
5593-961	0.0634	1.741	1.846	0.0640	1.756	1.862	0.0622	1.710	1.813	0.0593	1.637	1.736
Means:			1.970			1.962			1.904			1.910
						1.966						1.907

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES—Continued

Plate:	L623 (1) Dec. 10, 12:42, E.S.T.						L623 (2) Dec. 10, 12:43, E.S.T.					
De L. on T	$\alpha=0^\circ \quad \beta=7^\circ 2' \quad \gamma=19^\circ 9'$ $r=0.940 \quad \epsilon=0.266 \quad \phi=0^\circ 1'$ $B_0=-0^\circ 4' \quad 0.5318v = V$						$\alpha=0^\circ \quad \beta=7^\circ 2' \quad \gamma=10^\circ 9'$ $r=0.940 \quad \epsilon=0.266 \quad \phi=0^\circ 1'$ $B_0=-0^\circ 4' \quad 0.5318v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}t$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528-641	0.0600	1.678	1.785	0.0644	1.791	1.905	0.0660	1.833	1.949	0.0638	1.776	1.889
5535-061	0.0674	1.865	1.983	0.0664	1.839	1.956	0.0675	1.868	1.987	0.0740	2.035	2.164
5562-933	0.0721	1.974	2.099	0.0681	1.872	1.991	0.0621	1.719	1.828	0.0620	1.716	1.825
5569-848	0.0726	1.985	2.111	0.0687	1.887	2.007	0.0726	1.985	2.111	0.0707	1.937	2.060
5576-320	0.0687	1.882	2.002	0.0703	1.923	2.045	0.0677	1.857	1.975	0.0679	1.862	1.980
5578-946	0.0671	1.840	1.957	0.0695	1.901	2.022	0.0717	1.957	2.081	0.0700	1.914	2.036
5586-991	0.0695	1.898	2.019	0.0702	1.915	2.037	0.0695	1.898	2.019	0.0649	1.781	1.894
5588-985	0.0650	1.782	1.895	0.0680	1.858	1.976	0.0731	1.988	2.114	0.0702	1.914	2.036
5590-343	0.0708	1.928	2.050	0.0680	1.857	1.975	0.0655	1.794	1.908	0.0622	1.710	1.819
5593-961	0.0687	1.874	1.993	0.0679	1.854	1.972	0.0656	1.795	1.909	0.0660	1.805	1.920
Means:		1.989				1.989			1.988			1.962
						1.989						1.975
Plate:	L624 (1) Dec. 10, 1:02, E.S.T.						L624 (2) Dec. 10, 1:03, E.S.T.					
De L. on T	$\alpha=0^\circ \quad \beta=7^\circ 2' \quad \gamma=10^\circ 9'$ $r=0.940 \quad \epsilon=0.266 \quad \phi=0^\circ 1'$ $B_0=-0^\circ 4' \quad 0.5318v = V$						$\alpha=0^\circ \quad \beta=7^\circ 2' \quad \gamma=19^\circ 9'$ $r=0.940 \quad \epsilon=0.262 \quad \phi=0^\circ 1'$ $B_0=-0^\circ 4' \quad 0.5318v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}t$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528-641	0.0628	1.750	1.861	0.0634	1.766	1.878	0.0636	1.771	1.883	0.0593	1.660	1.765
5535-061	0.0707	1.950	2.074	0.0717	1.976	2.101	0.0614	1.711	1.820	0.0649	1.801	1.915
5562-933	0.0577	1.607	1.708	0.0628	1.737	1.847	0.0643	1.775	1.888	0.0646	1.783	1.896
5569-848	0.0666	1.832	1.948	0.0675	1.855	1.973	0.0692	1.898	2.019	0.0696	1.908	2.029
5576-320	0.0680	1.864	1.982	0.0634	1.747	1.858	0.0684	1.874	1.993	0.0717	1.958	2.082
5578-946	0.0677	1.855	1.973	0.0719	1.962	2.087	0.0644	1.771	1.883	0.0653	1.794	1.908
5586-991	0.0638	1.753	1.864	0.0662	1.814	1.929	0.0678	1.854	1.972	0.0661	1.811	1.926
5588-985	0.0673	1.840	1.956	0.0636	1.747	1.858	0.0700	1.909	2.030	0.0688	1.878	1.997
5590-343	0.0646	1.771	1.883	0.0677	1.850	1.967	0.0668	1.827	1.943	0.0664	1.817	1.932
5593-961	0.0627	1.722	1.831	0.0623	1.712	1.821	0.0706	1.922	2.044	0.0700	1.907	2.028
Means:		1.908				1.932			1.948			1.948
						1.920						1.948

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES—Continued

Plate:	L625 (1) Dec. 10, 1:10, E.S.T.						L627 (1) Dec. 12, 1:02, E.S.T.					
	$\alpha=0^\circ \beta=7^\circ 2' \gamma=19^\circ 9'$ $r=0.940 \epsilon=0.266 \phi=0^\circ 1'$ $B_0=-0^\circ 4' 0.5318v = V$						$\alpha=0^\circ \beta=6^\circ 8' \gamma=20^\circ 1'$ $r=0.939 \epsilon=0.267 \phi=0^\circ 1'$ $B_0=-2^\circ 6' 0.5324v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528-641	0.0662	1.838	1.955	0.0728	2.008	2.136	0.0607	1.696	1.806	0.0721	1.990	2.119
5535-061	0.0663	1.837	1.954	0.0697	1.924	2.046	0.0668	1.850	1.970	0.0626	1.742	1.855
5562-933	0.0673	1.852	1.970	0.0628	1.737	1.847	0.0643	1.775	1.890	0.0639	1.765	1.880
5569-848	0.0624	1.725	1.835	0.0690	1.893	2.013	0.0615	1.702	1.812	0.0633	1.748	1.861
5576-320	0.0635	1.750	1.861	0.0650	1.788	1.902	0.0717	1.958	2.085	0.0616	1.701	1.811
5578-946	0.0637	1.754	1.865	0.0608	1.680	1.787	0.0655	1.799	1.916	0.0643	1.769	1.884
5586-991	0.0667	1.827	1.943	0.0688	1.880	1.999	0.0646	1.773	1.888	0.0653	1.791	1.907
5588-985	0.0626	1.721	1.830	0.0693	1.891	2.011	0.0595	1.643	1.750	0.0652	1.787	1.903
5590-343	0.0604	1.665	1.771	0.0628	1.726	1.836	0.0694	1.893	2.016	0.0665	1.819	1.937
5593-961	0.0620	1.704	1.812	0.0683	1.864	1.982	0.0640	1.755	1.889	0.0658	1.800	1.917
Means:		1.880			1.956			1.900			1.907	
					1.918						1.904	
Plate:	L627 (2) Dec. 12, 1:03, E.S.T.						L628 (1) Dec. 12, 1:08, E.S.T.					
De L. on T	$\alpha=0^\circ \beta=6^\circ 8' \gamma=20^\circ 1'$ $r=0.939 \epsilon=0.267 \phi=0^\circ 1'$ $B_0=-2^\circ 6' 0.5324v = V$						$\alpha=0^\circ \beta=6^\circ 8' \gamma=20^\circ 1'$ $r=0.939 \epsilon=0.267 \phi=0^\circ 1'$ $B_0=-2^\circ 6' 0.5324v = V$					
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528-641	0.0650	1.807	1.924	0.0651	1.809	1.926	0.0652	1.811	1.929	0.0668	1.852	1.972
5535-061	0.0629	1.750	1.864	0.0666	1.845	1.965	0.0616	1.716	1.827	0.0610	1.700	1.810
5562-933	0.0655	1.806	1.923	0.0616	1.706	1.817	0.0642	1.772	1.887	0.0648	1.787	1.903
5569-848	0.0592	1.643	1.750	0.0612	1.694	1.804	0.0618	1.709	1.820	0.0674	1.852	1.972
5576-320	0.0618	1.706	1.817	0.0661	1.816	1.934	0.0666	1.828	1.946	0.0650	1.787	1.903
5578-946	0.0629	1.733	1.845	0.0625	1.723	1.835	0.0678	1.857	1.978	0.0714	1.949	2.075
5586-991	0.0685	1.872	1.993	0.0642	1.763	1.877	0.0747	2.029	2.161	0.0683	1.866	1.987
5588-985	0.0757	1.800	1.917	0.0664	1.818	1.936	0.0612	1.685	1.794	0.0538	1.497	1.594
5590-343	0.0632	1.736	1.849	0.0618	1.700	1.810	0.0556	1.542	1.642	0.0590	1.629	1.735
5593-961	0.0638	1.750	1.864	0.0671	1.833	1.952	0.0690	1.881	2.003	0.0665	1.817	1.935
Means:		1.875			1.886			1.899			1.889	
					1.881						1.894	

TABLE XIV—RESULTS FROM INDIVIDUAL OBSERVATIONS, 10 SPECTRUM LINES—Concluded

Plate:	L628 (2) Dec. 12, 1:09, E.S.T.							L629 (1) Dec. 12, 1:40, E.S.T.							
	$\alpha=0^\circ \beta=6^\circ 8 \gamma=20^\circ 1$			$\alpha=0^\circ \beta=6^\circ 8 \gamma=20^\circ 1$			$\alpha=0^\circ \beta=6^\circ 8 \gamma=20^\circ 1$			$\alpha=0^\circ \beta=6^\circ 8 \gamma=20^\circ 1$			$\alpha=0^\circ \beta=6^\circ 8 \gamma=20^\circ 1$		
De L. on T	$r=0.939 \epsilon=0.267 \phi=0^\circ 1$							$r=0.939 \epsilon=0.267 \phi=0^\circ 1$							
	$B_o=-2^\circ 6 0.5324v -V$			$B_o=-2^\circ 6 0.5324v -V$			$B_o=-2^\circ 6 0.5324v -V$			$B_o=-2^\circ 6 0.5324v -V$			$B_o=-2^\circ 6 0.5324v -V$		
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5528·641	0.0684	1.894	2.017	0.0685	1.897	2.020	0.0561	1.578	1.680	0.0779	2.139	2.278			
5535·061	0.0620	1.726	1.838	0.0620	1.726	1.838	0.0684	1.891	2.014	0.0678	1.875	1.997			
5562·933	0.0624	1.727	1.839	0.0621	1.719	1.831	0.0639	1.765	1.880	0.0670	1.844	1.964			
5569·848	0.0643	1.773	1.888	0.0639	1.763	1.877	0.0699	1.916	2.040	0.0697	1.911	2.035			
5576·320	0.0573	1.592	1.695	0.0641	1.765	1.880	0.0650	1.788	1.904	0.0677	1.857	1.978			
5578·946	0.0611	1.687	1.796	0.0597	1.652	1.759	0.0668	1.832	1.951	0.0674	1.848	1.968			
5586·991	0.0711	1.938	2.064	0.0746	2.027	2.159	0.0659	1.806	1.923	0.0704	1.920	2.045			
5588·985	0.0683	1.866	1.987	0.0678	1.853	1.973	0.0676	1.848	1.988	0.0699	1.906	2.030			
5590·343	0.0697	1.901	2.024	0.0699	1.906	2.030	0.0627	1.723	1.835	0.0646	1.771	1.886			
5593·961	0.0533	1.484	1.580	0.0675	1.843	1.963	0.0709	1.930	2.055	0.0665	1.818	1.936			
Means:		1.873			1.933				1.925			2.012			
					1.903							1.969			

TABLE XV—RESULTS FROM OBSERVATIONS, 6 SPECTRUM LINES

Plate:	L600 (1)–(5), Nov. 9, 3:20, E.S.T.				L601 (1)–(6), Nov. 9, 3:37, E.S.T.				L602 (1)–(6), Nov. 9, 3:50, E.S.T.						
	$\alpha=0^\circ \beta=6^\circ 4 \gamma=18^\circ 5$			$\alpha=0^\circ \beta=6^\circ 4 \gamma=18^\circ 5$			$\alpha=0^\circ \beta=6^\circ 4 \gamma=18^\circ 5$			$\alpha=0^\circ \beta=6^\circ 4 \gamma=18^\circ 5$					
DeL.on-C	$r=0.950 \epsilon=0.268 \phi=1^\circ 1$			$r=0.950 \epsilon=0.268 \phi=1^\circ 1$			$r=0.950 \epsilon=0.268 \phi=1^\circ 1$			$r=0.950 \epsilon=0.268 \phi=1^\circ 1$					
	$B_o=3^\circ 4 0.52724v -V$			$B_o=3^\circ 4 0.52724v -V$			$B_o=3^\circ 4 0.52724v -V$			$B_o=3^\circ 4 0.52724v -V$					
λ	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5586·991	0.0648	1.778	1.874	0.0676	1.849	1.949	0.0649	1.760	1.877	0.0697	1.902	2.005			
5587·800	0.0681	1.863	1.964	0.0674	1.844	1.944	0.0671	1.838	1.938	0.0689	1.883	1.986			
5588·084	0.0653	1.792	1.890	0.0663	1.814	1.912	0.0691	1.886	1.989	0.0667	1.826	1.925			
5588·985	0.0700	1.911	2.015	0.0652	1.788	1.885	0.0678	1.855	1.955	0.0687	1.878	1.980			
5589·582	0.0665	1.821	1.920	0.0675	1.848	1.948	0.0659	1.806	1.904	0.0662	1.813	1.912			
5590·343	0.0668	1.830	1.929	0.0677	1.851	1.952	0.0696	1.899	2.003	0.0690	1.886	1.989			
Means:		1.932			1.932				1.944			1.966			

TABLE XV—RESULTS FROM OBSERVATIONS, 6 SPECTRUM LINES—Continued

Plate:	L603 (1)–(5), Nov. 27, 2:02, E.S.T.			L606 (1)–(4), Dec. 5, 2:30, E.S.T.			L607 (1)–(5), Dec. 5, 2:40, E.S.T.			L608 (1)–(5), Dec. 6, 1:25, E.S.T.		
De L. on —C	$\alpha=0^\circ$ $r=0.948$ $B_o=1^\circ 2'$	$\beta=7^\circ 2'$ $\epsilon=0.268$ $0.5276v = V$	$\gamma=18^\circ 6'$ $\phi=0^\circ 4'$ $B_o=0^\circ 2'$	$\alpha=0^\circ 3$ $r=0.947$ $B_o=0^\circ 2$	$\beta=7^\circ 0$ $\epsilon=0.268$ $0.5276v = V$	$\gamma=18^\circ 6$ $\phi=0^\circ 3$ $B_o=0^\circ 2$	$\alpha=0$ $r=0.947$ $B_o=0^\circ 2$	$\beta=7^\circ 2$ $\epsilon=0.268$ $0.5276v = V$	$\gamma=18^\circ 6$ $\phi=0^\circ 0$ $B_o=0^\circ 2$	$\alpha=0^\circ$ $r=0.946$ $B_o=0^\circ 1$	$\beta=7^\circ 2$ $\epsilon=0.268\phi = 0^\circ 0$ $0.5285v = V$	$\gamma=18^\circ 6$ $\phi=0^\circ 0$ $B_o=0^\circ 1$
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5586-991	0.0639	1.756	1.852	0.0643	1.766	1.863	0.0636	1.748	1.845	0.0671	1.838	1.943
5587-800	0.0643	1.726	1.864	0.0652	1.792	1.891	0.0630	1.737	1.829	0.0656	1.779	1.880
5588-084	0.0660	1.808	1.908	0.0607	1.674	1.766	0.0629	1.731	1.827	0.0673	1.841	1.946
5588-985	0.0679	1.857	1.959	0.0648	1.778	1.876	0.0654	1.774	1.872	0.0685	1.872	1.979
5589-582	0.0705	1.923	2.029	0.0656	1.801	1.900	0.0664	1.819	1.919	0.0620	1.728	1.826
5590-343	0.0700	1.910	2.015	0.0652	1.789	1.887	0.0622	1.713	1.807	0.0678	1.854	1.960
Means:		1.938			1.864			1.850			1.923	
Plate:	L609 (1) Dec. 6, 1:45, E.S.T.			L609 (2) Dec. 6, 1:46, E.S.T.			L610 (4) Dec. 6, 1:55, E.S.T.			L610 (5) Dec. 6, 1:56, E.S.T.		
De L. on —C	$\alpha=0^\circ$ $r=0.946$ $B_o=0^\circ 1$	$\beta=7^\circ 2$ $\epsilon=0.267$ $0.5285v = V$	$\gamma=18^\circ 9$ $\phi=0^\circ 0$ $B_o=0^\circ 1$	$\alpha=0^\circ$ $r=0.946$ $B_o=0^\circ 1$	$\beta=7^\circ 2$ $\epsilon=0.267$ $0.5285v = V$	$\gamma=18^\circ 9$ $\phi=0^\circ 0$ $B_o=0^\circ 1$	$\alpha=0^\circ$ $r=0.946$ $B_o=0^\circ 1$	$\beta=7^\circ 2$ $\epsilon=0.267$ $0.5285v = V$	$\gamma=18^\circ 9$ $\phi=0^\circ 0$ $B_o=0^\circ 1$	$\alpha=0^\circ$ $r=0.946$ $B_o=0^\circ 1$	$\beta=7^\circ 2$ $\epsilon=0.267$ $0.5285v = V$	$\gamma=18^\circ 9$ $\phi=0^\circ 0$ $B_o=0^\circ 1$
λ	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5586-991	0.0640	1.758	1.858	0.0656	1.799	1.902	0.0678	1.855	1.961	0.0633	1.741	1.840
5587-800	0.0716	1.951	2.062	0.0736	2.002	2.116	0.0677	1.852	1.958	0.0597	1.649	1.743
5588-084	0.0727	1.970	2.092	0.0681	1.862	1.968	0.0640	1.758	1.858	0.0666	1.824	1.928
5588-985	0.0725	1.974	2.087	0.0646	1.774	1.875	0.0692	1.890	1.998	0.0708	1.930	2.040
5589-582	0.0656	1.799	1.902	0.0566	1.571	1.661	0.0701	1.913	2.022	0.0708	1.930	2.040
5590-343	0.0656	1.799	1.902	0.0679	1.857	1.963	0.0678	1.855	1.961	0.0689	1.883	1.990
Means:		1.984			1.914			1.960			1.930	
Plate:	L611 (1) Dec. 6, 2:48, E.S.T.			L611 (2) Dec. 6, 2:49, E.S.T.			L613 (1) Dec. 8, 1:18, E.S.T.			L613 (6) Dec. 8, 1:19, E.S.T.		
De L. on —C	$\alpha=0^\circ$ $r=0.952$ $B_o=0^\circ 1$	$\beta=7^\circ 2$ $\epsilon=0.269$ $0.5251v = V$	$\gamma=17^\circ 8$ $\phi=0^\circ 0$ $B_o=0^\circ 1$	$\alpha=0^\circ$ $r=0.952$ $B_o=0^\circ 1$	$\beta=7^\circ 2$ $\epsilon=0.269$ $0.5251v = V$	$\gamma=17^\circ 8$ $\phi=0^\circ 0$ $B_o=0^\circ 1$	$\alpha=0^\circ$ $r=0.945$ $B_o=0^\circ 2$	$\beta=7^\circ 2$ $\epsilon=0.267$ $0.5291v = V$	$\gamma=19^\circ 1$ $\phi=0^\circ 0$ $B_o=0^\circ 2$	$\alpha=0^\circ$ $r=0.945$ $B_o=0^\circ 2$	$\beta=7^\circ 2$ $\epsilon=0.267$ $0.5291v = V$	$\gamma=19^\circ 1$ $\phi=0^\circ 0$ $B_o=0^\circ 2$
λ	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5586-991	0.0680	1.861	1.954	0.0678	1.856	1.949	0.0684	1.870	1.979	0.0691	1.888	1.998
5587-800	0.0688	1.881	1.975	0.0655	1.797	1.887	0.0561	1.812	1.917	0.0630	1.733	1.834
5588-084	0.0665	1.823	1.915	0.0742	2.018	2.119	0.0681	1.862	1.970	0.0654	1.794	1.898
5588-985	0.0693	1.894	1.989	0.0720	1.962	2.060	0.0681	1.862	1.970	0.0650	1.784	1.888
5589-582	0.0774	2.099	2.024	0.0710	1.937	2.034	0.0681	1.862	1.970	0.0745	2.025	2.143
5590-343	0.0695	1.899	1.994	0.0708	1.932	2.029	0.0661	1.812	1.917	0.0647	1.776	1.879
Means:		2.005			2.013			1.954			1.940	

TABLE XV—RESULTS FROM OBSERVATIONS, 6 SPECTRUM LINES—Continued

Plate:	L614 (1) Dec. 8, 1:38, E.S.T.			L614 (2) Dec. 8, 1:39, E.S.T.			L614a (1) Dec. 8, 2:02, E.S.T.			L615 (1) Dec. 8, 2:15, E.S.T.		
	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 4$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 4$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 3$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 1$
De L. on -C	r=0.943	$\epsilon=0.267$	$\phi=0^\circ 0$	r=0.943	$\epsilon=0.267$	$\phi=0^\circ 0$	r=0.944	$\epsilon=0.267$	$\phi=0^\circ 0$	r=0.945	$\epsilon=0.267$	$\phi=0^\circ 0$
	$B_o=0^\circ 2$	$0.5301v = V$		$B_o=0^\circ 2$	$0.5301v = V$		$B_o=0^\circ 2$	$0.5298v = V$		$B_o=0^\circ 2$	$0.5291v = V$	
λ	d'	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5586.991	0.0690	1.885	1.998	0.0645	1.771	1.878	0.0652	1.789	1.896	0.0632	1.738	1.839
5587.800	0.0655	1.796	1.904	0.0682	1.865	1.977	0.0650	1.784	1.890	0.0728	1.982	2.097
5588.084	0.0614	1.692	1.794	0.0683	1.867	1.979	0.0652	1.789	1.896	0.0701	1.913	2.024
5588.985	0.0628	1.728	1.832	0.0628	1.728	1.832	0.0716	1.951	2.067	0.0688	1.880	1.989
5589.582	0.0579	1.604	1.701	0.0631	1.735	1.839	0.0645	1.771	1.877	0.0736	2.002	2.119
5590.343	0.0720	1.983	2.102	0.0616	1.697	1.799	0.0692	1.890	2.003	0.0709	1.933	2.046
Means:		1.889			1.884			1.938			2.019	
Plate:	L616 (1) Dec. 9, 9:12, E.S.T.			L616 (2) Dec. 9, 12:43, E.S.T.			L617 (1) Dec. 9, 12:52, E.S.T.			L617 (2) Dec. 9, 12:53, E.S.T.		
De L. on -C	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 9$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 9$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 9$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 9$
	r=0.940	$\epsilon=0.266$	$\phi=0^\circ 1$	r=0.940	$\epsilon=0.266$	$\phi=0^\circ 1$	r=0.940	$\epsilon=0.266$	$\phi=0^\circ 1$	r=0.940	$\epsilon=0.266$	$\phi=0^\circ 1$
	$B_o=0^\circ 3$	$0.5318v = V$		$B_o=0^\circ 3$	$0.5318v = V$		$B_o=0^\circ 3$	$0.5318v = V$		$B_o=0^\circ 3$	$0.5318v = V$	
λ	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5586.991	0.0648	1.778	1.891	0.0605	1.668	1.774	0.0595	1.643	1.747	0.0651	1.785	1.899
5587.800	0.0591	1.633	1.737	0.0657	1.800	1.914	0.0644	1.767	1.879	0.0646	1.773	1.886
5588.084	0.0601	1.658	1.763	0.0636	1.747	1.858	0.0703	1.917	2.039	0.0732	1.991	2.118
5588.985	0.0613	1.691	1.799	0.0663	1.816	1.931	0.0595	1.643	1.747	0.0654	1.793	1.907
5589.582	0.0662	1.813	1.928	0.0710	1.935	2.058	0.0654	1.793	1.907	0.0652	1.788	1.902
5590.343	0.0658	1.803	1.918	0.0674	1.844	1.961	0.0698	1.905	2.026	0.0636	1.747	1.858
Means:		1.839			1.916			1.891			1.928	
Plate:	L618 (1) Dec. 9, 1:12, E.S.T.			L618 (2) Dec. 9, 1:14, E.S.T.			L619 (1) Dec. 9, 1:20, E.S.T.			L620 (1) Dec. 9, 1:35, E.S.T.		
De L. on -C	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 9$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 9$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 9$	$\alpha=0^\circ$	$\beta=7^\circ 2$	$\gamma=19^\circ 9$
	r=0.940	$\epsilon=0.266$	$\phi=0^\circ 1$	r=0.940	$\epsilon=0.266$	$\phi=0^\circ 1$	r=0.940	$\epsilon=0.266$	$\phi=0^\circ 1$	r=0.943	$\epsilon=0.267$	$\phi=0^\circ 1$
	$B_o=-0^\circ 3$	$0.5318v = V$		$B_o=-0^\circ 3$	$0.5318v = V$		$B_o=-0^\circ 3$	$0.5318v = V$		$B_o=-0^\circ 3$	$0.5318v = V$	
λ	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5586.991	0.0669	1.831	1.947	0.0630	1.732	1.842	0.0584	1.615	1.718	0.0623	1.715	1.818
5587.800	0.0787	2.130	2.265	0.0644	1.767	1.879	0.0674	1.844	1.961	0.0664	1.819	1.929
5588.084	0.0754	2.047	2.177	0.0640	1.757	1.869	0.0678	1.854	1.972	0.0586	1.621	1.719
5588.985	0.0679	1.856	1.974	0.0685	1.872	1.991	0.0634	1.742	1.853	0.0655	1.796	1.904
5589.582	0.0670	1.833	1.950	0.0505	1.415	1.505	0.0782	2.118	2.253	0.0579	1.604	1.698
5590.343	0.0709	1.932	2.055	0.0608	1.676	1.783	0.0695	1.897	2.018	0.0688	1.880	1.993
Means:		2.061			1.812			1.963			1.844	

TABLE XV—RESULTS FROM OBSERVATIONS, 6 SPECTRUM LINES—Concluded

Plate:	L624 (1) Dec. 10, 1:02, E.S.T.			L624 (2) Dec. 10, 1:03, E.S.T.			L625 (1) Dec. 10, 1:10, E.S.T.			L627 (1) Dec. 12, 1:02, E.S.T.		
	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$
λ	d'	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
De L. on -C	$\alpha=0^\circ$ $r=0.943$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.267$ $0.5301v = V$	$\gamma=19^\circ 4'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.943$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.267$ $0.5301v = V$	$\gamma=19^\circ 4'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$
Means:		2.020				1.975				1.875		1.861
Plate:	L622 (1) Dec. 10, 12:32, E.S.T.			L622 (2) Dec. 10, 12:33, E.S.T.			L623 (1) Dec. 10, 12:42, E.S.T.			L623 (2) Dec. 10, 12:43, E.S.T.		
	$\alpha=0^\circ$ $r=0.943$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.267$ $0.5301v = V$	$\gamma=19^\circ 4'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.943$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.267$ $0.5301v = V$	$\gamma=19^\circ 4'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$
λ	d'	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
De L. on -C	$\alpha=0^\circ$ $r=0.943$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.267$ $0.5301v = V$	$\gamma=19^\circ 4'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.943$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.267$ $0.5301v = V$	$\gamma=19^\circ 4'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.940$ $B_o=-0.4$	$\beta=7^\circ 2'$ $\epsilon=0.266$ $0.5318v = V$	$\gamma=19^\circ 9'$ $\phi=0^\circ 1'$
Means:		1.822				1.874				2.008		1.867
Plate:	L627 (2) Dec. 12, 1:03, E.S.T.			L628 (1) Dec. 12, 1:08, E.S.T.			L628 (2) Dec. 12, 1:09, E.S.T.			L629 (1) Dec. 12, 1:40, E.S.T.		
	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$
λ	d'	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d''	$\frac{1}{2}v$	V	d'	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
De L. on -C	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$	$\alpha=0^\circ$ $r=0.939$ $B_o=-2^\circ 6$	$\beta=6^\circ 8'$ $\epsilon=0.267$ $0.5324v = V$	$\gamma=20^\circ 1'$ $\phi=0^\circ 1'$
Means:		1.845				1.791				1.984		1.915

The order of the micrometer-settings on the spectrum lines in the measurements of these 68 observations was that used in many of the later observations containing 7 and 9 strips of spectrum. The settings are commenced on one of the outside strips of spectrum and carried through with 2 settings on each line in each strip, thus, top, middle, bottom, bottom, middle, top. If the "oil error" is present it will be detected, and the error in the measured displacement greatly reduced as compared to the method of making 4 settings on the middle strip followed by 2 settings on each of the outside strips. The difference between the measurements of the plate in the violet left and violet right positions will be small, and the mean of the two will be practically freed from the oil error if it be present. An inspection of the oil-error curves of motion of the plate with time, given in this Volume, Part I, p. 21, will make this clear, keeping in mind that the 6 settings involved required about 1 minute to make.

DISCUSSION OF RESULTS

Mean Velocity.—The mean velocities for the 32 observations on which 10 spectrum lines were measured, taken from Table XIV, are summarized in Table XVI, where the values for plate violet left and right are given together with the means of these. Thus, it is seen that the mean of the violet left and violet right measurements, 1.929 and 1.937 km. per sec., respectively, differ by only 0.008 km. per sec., a quantity so small that it may be assumed to be accidental, in other words, the oil error would seem to be practically eliminated from the mean measurements. The mean value of the equatorial velocity of rotation derived from the double measurement of 10 spectrum lines, of average intensity 3.9 and average chromospheric elevation 495 km., is 1.933 km. per sec. In Table XVII is a summary of mean velocities of the whole series of 68 plates

TABLE XVI—SUMMARY OF MEAN VELOCITIES, 32 OBSERVATIONS, 10 SPECTRUM LINES

Observation		V km./sec.			Observation		V km./sec.		
L	1910	(Left)	(Right)	Mean	L	1910	(Left)	(Right)	Mean
609 (1)	Dec. 6	1.938	1.926	1.932	618 (1)	Dec. 9	1.923	1.896	1.910
(2)	" 6	1.940	1.955	1.948	(2)	" 9	1.919	1.875	1.897
610 (4)	" 6	1.976	1.986	1.981	619 (1)	" 9	1.908	1.888	1.898
(5)	" 6	1.965	1.967	1.966	620 (1)	" 9	1.823	1.868	1.846
611 (1)	" 6	1.925	1.968	1.947	622 (1)	" 10	1.970	1.962	1.966
(2)	" 6	1.982	2.025	2.004	(2)	" 10	1.904	1.910	1.907
613 (1)	" 8	2.017	2.015	2.016	623 (1)	" 10	1.989	1.989	1.989
(6)	" 8	1.945	1.876	1.911	(2)	" 10	1.988	1.962	1.975
614 (1)	" 8	1.968	1.926	1.947	624 (1)	" 10	1.908	1.932	1.920
(2)	" 8	1.872	1.952	1.912	(2)	" 10	1.948	1.948	1.948
614a (1)	" 8	1.964	1.981	1.973	625 (1)	" 10	1.880	1.956	1.918
615 (1)	" 8	2.025	2.014	2.020	627 (1)	" 12	1.900	1.907	1.904
616 (1)	" 9	1.882	1.870	1.876	(2)	" 12	1.875	1.886	1.881
(2)	" 9	1.915	1.929	1.922	628 (1)	" 12	1.899	1.889	1.894
617 (1)	" 9	1.858	1.884	1.871	(2)	" 12	1.873	1.933	1.903
(2)	" 9	1.927	1.912	1.920	629 (1)	" 12	1.925	2.012	1.969
Means:							1.920	1.937	1.933

from 6 spectrum lines measured either violet left or right. In Table XV, the results for individual observations are given for the 32 observations only, L609 (1)–L629 (1), so that the measurements may be compared with the 10 line measurements of the same plates; while only the means for each plate, L600–L608, 4 to 6 observations on each plate, 36 observations in all, are given, to save printing space. In Table XVIII, the mean velocity for the series of 36 and 32 observations, and the combined series of 68 observations, along with the mean displacements and the derived velocities for the 6 spectrum lines, are given together with the mean observational quantities, since these vary little throughout the series. Thus, it is seen that the 32 observations, L609 (1)–L629 (1), using 6 spectrum lines of average intensity 2.8 and average chromospheric elevation 433 km., yield a mean value for the equatorial velocity of rotation of 1.923

TABLE XVII—SUMMARY OF MEAN VELOCITIES, 68 OBSERVATIONS, 6 SPECTRUM LINES

Observation			V km./sec.		Observation			V km./sec.	
L	1910		(Left)	(Right)	L	1910		(Left)	(Right)
600 (1)	Nov.	9	.....	1.991	608 (4)	Dec.	6	.....	1.877
(2)	"	9	.....	1.877	(5)	"	6	.....	1.970
(3)	"	9	.....	1.875	609 (1)	"	6	.....	1.984
(4)	"	9	.....	1.961	(2)	"	6	.....	1.914
(5)	"	9	.....	1.957	610 (4)	"	6	1.960	
601 (1)	"	9	1.953		(5)	"	6	1.930	
(2)	"	9	1.951		611 (1)	"	6	2.005	
(3)	"	9	1.912		(2)	"	6	2.013	
(4)	"	9	1.948		613 (1)	"	8	.....	1.954
(5)	"	9	1.915		(6)	"	8	.....	1.940
(6)	"	9	1.912		614 (1)	"	8	1.889	
602 (1)	"	9	.....	1.916	(2)	"	8	1.884	
(2)	"	9	.....	1.932	614a (1)	"	8	.....	1.938
(3)	"	9	.....	2.100	615 (1)	"	8	2.019	
(4)	"	9	.....	1.952	616 (1)	"	9	.....	1.839
(5)	"	9	.....	1.931	(2)	"	9	.....	1.916
(6)	"	9	.....	1.966	617 (1)	"	9	1.891	
603 (1)	"	27	1.953		(2)	"	9	1.928	
(2)	"	27	2.068		618 (1)	"	9	.....	2.061
(3)	"	27	1.809		(2)	"	9	.....	1.812
(4)	"	27	1.968		619 (1)	"	9	1.963	
(5)	"	27	1.891		620 (1)	"	9	.....	1.844
606 (1)	Dec.	5	.....	1.891	622 (1)	"	10	1.822	
(2)	"	5	.....	1.910	(2)	"	10	1.874	
(3)	"	5	.....	1.837	623 (1)	"	10	.....	2.008
(4)	"	5	.....	1.817	(2)	"	10	.....	1.867
607 (1)	"	5	1.834		624 (1)	"	10	2.020	
(2)	"	5	1.799		(2)	"	10	1.975	
(3)	"	5	1.862		625 (1)	"	10	.....	1.875
(4)	"	5	1.885		627 (1)	"	12	1.861	
(5)	"	5	1.869		(2)	"	12	1.845	
608 (1)	"	6	.....	1.894	628 (1)	"	12	.....	1.791
(2)	"	6	.....	1.950	(2)	"	12	.....	1.984
(3)	"	6	.....	1.922	629 (1)	"	12	1.915	
Means:								1.919	1.922

km. per sec., as compared with the value 1.933 km. per sec. noted above for the 10 spectrum lines. The other 36 observations yield a mean velocity of 1.918 km. per sec.; and the mean for the whole series of 68 observations is 1.920 km. per sec.

TABLE XVIII—SUMMARY OF MEAN DISPLACEMENTS AND DERIVED VELOCITIES FOR
6 SPECTRUM LINES, 36, 32, AND 68 OBSERVATIONS

Plates:	36 Observations			32 Observations			68 Observations		
	L600 (1) to L608 (5)			L609 (1) to L629 (1)			L660 (1) to 629 (1)		
	$\alpha = 0^\circ$	$\beta = 6^\circ 8$	$\gamma = 18^\circ 6$	$\alpha = 0^\circ$	$\beta = 7^\circ 1$	$\gamma = 19^\circ 5$	$\alpha = 0^\circ$	$\beta = 6^\circ 9$	$\gamma = 19^\circ 1$
De L. on -C	$r = 0.948$	$\epsilon = 0.268$	$\phi = 0^\circ 6$	$r = 0.942$	$\epsilon = 0.267$	$\phi = 0^\circ 1$	$r = 0.945$	$\epsilon = 0.268$	$\phi = 0^\circ 3$
	$B_0 = 1.98$	$0.5276v$	$= V$	$B_0 = 0.96$	$0.5306v$	$= V$	$B_0 = 0.96$	$0.5291v$	$= V$
λ	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V	d	$\frac{1}{2}v$	V
	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.	mm.	km./sec.	km./sec.
5586.991	0.0660	1.810	1.910	0.0656	1.797	1.907	0.0658	1.804	1.909
5587.800	0.0662	1.813	1.912	0.0666	1.823	1.934	0.0664	1.818	1.923
5588.084	0.0652	1.789	1.887	0.0665	1.822	1.933	0.0658	1.804	1.910
5588.985	0.0673	1.838	1.939	0.0663	1.817	1.928	0.0668	1.829	1.934
5589.582	0.0664	1.823	1.923	0.0649	1.780	1.889	0.0657	1.801	1.906
5590.343	0.0671	1.834	1.937	0.0670	1.833	1.945	0.0670	1.834	1.942
Means:	0.0664	1.818	1.918	0.0662	1.812	1.923	0.0663	1.815	1.920
" 1, 4, 6:	0.0668	1.829	1.929	0.0663	1.816	1.927	0.0665	1.822	1.928
" 2, 3, 5:	0.0660	1.808	1.908	0.0660	1.808	1.919	0.0660	1.808	1.913
p.r. Single observation:			$\pm .043$			$\pm .047$			$\pm .045$
p.r. Mean:			$\pm .007$			$\pm .008$			$\pm .005$

Mean Velocities for Individual Spectrum Lines, and the Question of the Cause of Their Differences.—In Tables XIX and XX, are given summaries of the equatorial velocities of rotation, derived from individual spectrum lines, for the groups of 10 and 6 lines respectively. Groupings of the individual values with elevations and with different degrees of strengthening in the "flash" spectrum are given in the former table, and with elevations and intensities in the latter.

It is seen from Table XIX that for a range of elevations in the chromosphere from 600 to 350 km. the velocity of rotation is progressively lower from 1.943 km. per sec. to 1.906 km. per sec. This is rather surprising in view of the fact that for the $\lambda 4500$ observations (discussed in the preceding section) differences of about 1400 km. and 2000 km. made little difference in the rotational velocity of two groups of spectrum lines, and the slight difference found indicated the greater velocity for the lower level. One must therefore be skeptical of the interpretation that a difference of 250 km. in elevation would result in a difference of velocity of rotation of 0.037 km. per sec. in this $\lambda 5600$ region of the spectrum. By grouping the lines as to their relative strengthening in the flash spectrum another progression results, showing a difference of 0.024 km. per sec. in rotational velocity between lines greatly strengthened and those not strengthened or somewhat weakened in the flash. In Table XX, the group of 6 lines used in many later

TABLE XIX—SUMMARY OF THE MEAN VALUES OF THE EQUATORIAL VELOCITY OF ROTATION FOR 10 SPECTRUM LINES, 32 OBSERVATIONS, 1910

Sun				Chromo-sphere		Rotational velocity								
λ Rowland	λ I.A.	Element	Int.	Int.	Height	Mean	Heights in km.				Strength in flash			
							600	500	400	350	Strong	Medium	Weak	
\AA					km.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	
5528.641	.420	Mg	8	8	400	1.945	.....	.....	1.945	.....	.....	.....	.....	1.945
5535.061	4.849	Fe ⁺	2	15	600	1.963	1.963	.....	.....	.....	1.963	.....	.....
5562.933	.718	Fe	2	2	350	1.906	.....	.....	.....	1.906	.....	.....	.....	1.906
5569.848	.633	Fe	6	7	600	1.938	1.938	.....	.....	.....	.....	.....	1.938	
5576.320	.101	Fe	4	6	500	1.931	.....	1.931	.....	.....	.....	.....	1.931	
5578.946	.731	Ni	1	4	500	1.937	.....	1.937	.....	.....	1.937	.....	.....
5586.991	.773	Fe	7	8	600	1.930	1.930	.....	.....	.....	.....	.....	1.930	
5588.985	.766	Ca	6	6	600	1.939	1.939	.....	.....	.....	.....	.....	.....	1.939
5590.343	.128	Ca	3	1	400	1.914	.....	.....	1.914	.....	.....	.....	.....	1.914
5593.961	.748	Ni	0	1d	400	1.930	.....	.....	1.930	.....	.....	.....	1.930	
Means:						1.933	1.943	1.934	1.930	1.906	1.950	1.932	1.926	

TABLE XX—SUMMARY OF THE MEAN VALUES OF THE EQUATORIAL VELOCITY OF ROTATION FOR 6 SPECTRUM LINES, 68 OBSERVATIONS, 1910

Sun				Chromosphere		Rotational velocity								
λ Rowland	λ I.A.	Element	Int.	Int.	Height	Mean	Heights in km.			Intensity				
							600	400	300	Strong	Weak			
\AA					km.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	km./sec.	
5586.991	.773	Fe	7	8	600	1.909	1.909	.....	.....	.....	1.909	.....	.....
5587.800	.583	Fe	0	1	300	1.923	.....	.....	1.923	.....	.....	1.923	.....	1.923
5588.084	7.870	Ni	1	4	400	1.910	.....	1.910	.....	.....	.....	.....	.....	1.910
5588.985	.766	Ca	6	6	600	1.934	1.934	.....	.....	.....	1.934	.....	.....
5589.582	.368	Ni	0	1	300	1.906	.....	.....	1.906	.....	.....	1.906	.....	1.906
5590.343	.128	Ca	3	1	400	1.941	.....	1.941	.....	.....	1.941	.....	.....
Means:						1.920	1.922	1.926	1.915	1.928	1.913	.....	.....

rotation observations, and measured also in the artificial blends of centre and limb spectra, show the characteristic difference due to blended spectra in that the 3 strong lines yield an average velocity of 1.928 km. per sec., while the 3 weak lines have a mean value of 1.913 km. per sec. (An outline of results found in blended spectra has been given in the Introduction of Section 1, preceding.) The difference in velocity exhibited with elevation is not great enough to be significant for these 6 lines with a range of 300 km. in height. The conclusion must consequently be drawn that, in the main, the differences in velocity found for the different spectrum lines are due to the blended spectrum of haze, which is usually fairly bright in December.

In the results in Table XIX, a striking difference in velocity, 0.057 km. per sec., is seen for the lines $\lambda 5535$ and $\lambda 5562$, both of intensity 2, the former due to Fe^+ and the latter to Fe. The former line is greatly increased in intensity in the flash spectrum, relatively to the latter line. This difference in rotational velocity is surely not ascribable to the small difference of 250 km. in elevation. It may denote a real difference in velocity, but further work with these lines, particularly in blended spectra and with different degrees of haziness, is desirable.

Summary of the Determinations of the Equatorial Velocity of Rotation in 1909 and 1910.—The results of the measurements of the solar equatorial velocity in 1909 and 1910, the bridge years between the high values of preceding years and the low values of subsequent years, may be briefly outlined as follows:—

1. In 1909, 11 observations of poor quality at $\lambda 4250$ and $\lambda 4500$ yielded a mean value of the equatorial velocity of 1.94 km. per sec.
2. In 1910, 32 observations of fair quality at $\lambda 4500$ yielded a mean value of 1.950 km. per sec. for the equatorial velocity from the measurements of 12 spectrum lines made twice by each of two observers; while 46 observations of fair quality, 6 lines measured once for each observation by one observer, gave a mean value of 1.931 km. per sec.; and the mean of the 78 observations was 1.940 km. per sec.
3. In 1910, 32 observations of good quality at $\lambda 5600$ gave a mean value of 1.933 km. per sec. for the equatorial velocity derived from the measurement of 10 spectrum lines, twice for each observation, by one observer; and 68 observations of fair quality at $\lambda 5600$, 6 lines measured once for each observation, by one observer, yielded a mean equatorial velocity of 1.920 km. per sec.
4. The theory that increased velocity of rotation accompanies increased elevation in the solar atmosphere is not supported by the observations at $\lambda 4500$, but rather the reverse; while differences in velocity for different spectrum lines at $\lambda 5600$ are ascribable to the depressing influence of blended spectrum of terrestrial haze. A striking difference in velocity between an Fe^+ and an Fe line, both of intensity 2, may indicate a real difference in velocity of rotation, too great to be ascribed to the small difference in elevation of 250 km., though this difference may also be due to the blended spectrum of haze.

DOMINION OBSERVATORY,
OTTAWA,

June 1, 1936.

