CIHM
Microfiche
Series
(Monographs)

ICMH
Collection de
microfiches
(monographies)

Canadian Institute for Historical Microreproductions / Institut canadien de microreproductions historiques

Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming are checked below.

- [x] Coloured covers / Couverture de couleur
- [x] Covers damaged / Couverture endommagée
- [ ] Covers restored and/or laminated / Couverture restaurée et/ou pelliculée
- [ ] Cover title missing / Le titre de couverture manque
- [ ] Coloured maps / Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black) / Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations / Planches et/ou illustrations en couleur
- [ ] Bound with other material / Relié avec d'autres documents
- [ ] Only edition available / Seule édition disponible
- [ ] Tight binding may cause shadows or distortion along interior margin / La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure.
- [ ] Blank leaves added during restorations may appear within the text. Whenever possible, these have been omitted from filming / Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

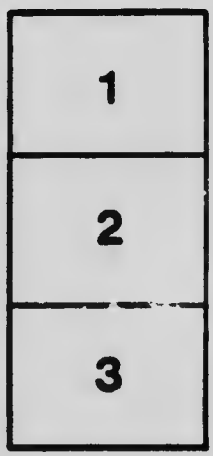
- [ ] Coloured pages / Pages de couleur
- [ ] Pages damaged / Pages endommagées
- [ ] Pages restored and/or laminated / Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed / Pages décolorées, tachetées ou piquées
- [ ] Pages detached / Pages détachées
- [x] Showthrough / Transparence
- [x] Quality of print varies / Qualité inégale de l'impression
- [ ] Includes supplementary material / Comprend du matériel supplémentaire
- [ ] Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image / Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.
- [ ] Opposing pages with varying colouration or discolourations are filmed twice to ensure the best possible image / Les pages s'opposant ayant des colorations variables ou des décolorations sont filmées deux fois afin d'obtenir la meilleure image possible.

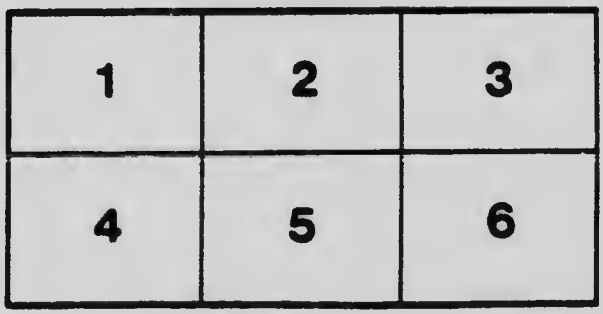
- [x] Additional comments / Commentaires supplémentaires:

Pagination is as follows: p. [201]-219.
La pagination est comme suit: p. [201]-219.

This item is filmed at the reduction ratio checked below / Ce document est filmé au taux de réduction indiqué ci-dessous.

10x	12x	14x	16x	18x	20x	22x	24x	26x	28x	30x	32x
							✓				





REPRINTED FROM THE JOURNAL
OF THE ROYAL ASTRONOMI
CAL SOCIETY OF CANADA
MAY JUNE, 1917

SOME MEASUREMENTS OF BLENDED SPECTRA

BY

RALPH DELEY,
DOMINION OBSERVATORY, OTTAWA

SOME MEASUREMENTS OF BLENDED SPECTRA

By Ralph E. Deluky

IN any source of emission or absorption of light, the conditions of the systems, whose vibrations or oscillations account for spectrum lines, are so varied that the lines are never free from the effects of blending. Furthermore, in solar and astrophysical investigations the possibility of the blending of the radiations from several sources arises. Hence it is important that the effects of blending on the measurements of the lines be known. This point was raised by me several years ago,* and the method of blending known spectra in known ways and measuring the resulting lines was suggested as a necessary step in such investigations as the determination of the rate of rotation of eclipsing variables, the presence of a haze or halo of independently moving matter between the observer and the source of light, spectroscopic binaries, etc.; and some few measurements were given of solar rotation spectra blended with sky spectrum. The following measurements of plates taken in 1911 and 1912 and measured shortly afterwards, were made in accordance with those sugges-

* Report of the Chief Astronomer, 1911, p. 281-4.

tions. Their publication has been delayed in the hope that, with the aid of certain special apparatus, the factors of photographic action, personal interpretation and characters of the spectra blended, could be thoroughly investigated; however, since the results already obtained are quite definite and seem important, they are herewith published.

The method of taking the plates was to expose for a number of seconds, l, on the limbs, using the 23 foot spectrograph with the equipment for observing the rate of the solar rotation by photographing spectra of two opposite limbs simultaneously,* then to move the sun's image so that the centre of the disc fell on the two limb windows in turn, exposing for the same time, c seconds, through each. These times are given in the following Table of Observational Data, for exposures (1) to (10). Exposure (1) is of the limbs alone: exposure (10) consists of a centre strip of spectrum from the centre of the disc, and two outside strips from the receding limb of the sun. In the first column of the table are given the numbers of the plates; in the second the position angle of the limb observations, *i. e.*, the angle between the equatorial diameter of the disc and the diameter joining the limb windows; in the third the ratio of distance of limb window from centre to radius of disc. From exposures $l.915$ (10) and $l.917$ (10) it is deduced that equal densities of continuous spectrum are obtained by exposures of 50 seconds from a point 0·97 of radius from centre and 21 seconds at centre; and from Abbot's "The Sun," p. 107, it follows that the intensities of these two points for $\lambda 5600$ are in the ratio 1 : 1·8. Consequently, Density = Intensity × time$^{\cdot 7}$ for the Cramer's Iso. Process plates used. Hence, in an exposure of l seconds, limb, followed by an exposure of c seconds, centre, the ratio of density of the *continuous spectrum* from the limb exposure to the total density of the exposure, is,

$$R \quad c_1^{\cdot 7} : (c_1 + c)^{\cdot 7}, \text{ where } 1{\cdot}8\, c_1^{\cdot 7} = l^{\cdot 7}$$
$$l^{\cdot 7} : (l + l_1)^{\cdot 7}, \text{ where } l_1^{\cdot 7} = 1{\cdot}8\, c^{\cdot 7}.$$

* Report of the Chief Astronomer, 1910 and 1911.

For plate *L*854, the ratio of brightness limb (at 0·91 radius) to centre is 1 : 1·6; hence, in the above formula, 1·6 replaces 1·8. The values of *R* given in the Table of Observational Data and at the heads of columns in the subsequent tables are computed for the various degrees of blending from the above formula.

TABLE OF OBSERVATIONAL DATA

Plate	Pos. Ang.	Limb Dist.	(1) *l*	*c*	(2) *l*	*c*	(3) *l*	*c*	(4) *l*	*c*	(5) *l*	*c*	(6) *l*	*c*	(7) *l*	*c*	(8) *l*	(9) *l*	(10) *l*	*c*
L854	0°	0·91	40		39,	1 38,	2 36,		4 32,		8 28,		12							(not blended)
		R	1·00		0·89	0·83	0·74		0·62		0·54									
L911	75°	0·97	50,	0 45,	3 5 40,		7 35,	10 5 30,		15 5 25,		17 5 23,		23 5 15,		24 5 10,	28			
		R	1·00		0·89	0·79	0·69		0·58		0·51		0·43		0·33		0·24			
L912	60°	0·97	50,	3 5 50,		0 40,	7 35,	10 5 30,		14 5 20,		21 25,	17 5 15,		24 5 10,	28				
		R	0·90		1·00	0·79	0·69		0·60		0·42		0·51		0 33		0·24			
L913	45°	0·97	50,	0 45,	3 5 40,		7 35,	10 5 30,		14 5 25,		18 5 20,		21 15,	24 5 10,	28				
		R	1·00		0·89	0·79	0 69		0 60		0 51		0·42		0 33		0 24			
L914	30°	0·97	50,	0 45,	3 5 40,		7 35,	10 5 30,		14 25,	17 5 20,		21 15,	24 5 10,	28					
		R	1 00		0·89	0 79	0·69		0·60		0·51		0·42		0 33		0 24			
L915	15°	0·97	50,	0 45,	3 5 40,		7 5 35,	10 5 30,		14 5 25,	17 5 20,		21 5 15,	24 5 10,	28	50	"			
		R	1·00		0·89	0·79	0·69		0 60		0·51		0·42		0·33		0 24			
L917	0°	0·97	50,	0 45,	3 5 40,		7 5 35,	10 5 30,		14 5 25,	17 5 20,		21 15,	24 5 10,	28	"	20			
		R	1·00		0 89	0·79	0·69		0 60		0·51		0·42		0·33		0·24			

$$R = I_0 7 \div (I + I_1)0\cdot7, \text{ where } I_1 0\cdot7 = 1\cdot8\, I_0 0\cdot7$$

$$c_1 0\cdot7 = (c_1 + c)0\cdot7, \text{ where } I 0\cdot7 = 1\cdot8\, I_0 0\cdot7$$

In making the measurements given in the following tables, the Toepfer measuring machine, (readings to 0·001 mm. and estimations to 0·0001 mm.), was used in the same way as for measuring solar rotation displacements, namely, 4 settings on the middle strip (one limb and its blend with centre spectrum), and 2 settings on each outside strip (other limb with its blend with centre). The scale of the plates is 1 Å. u. = 1·42 mm. Half measured displacements and half line-widths were reduced to km./sec. by multiplying by the same factors as used in the determination of solar rotation (varying from 19·34 line 1, to 18·29 line 19). The results of *L*854 are given for each of the 19 spectral lines selected in the 1911 series of solar rotation plates at λ5600, (Table I*a*); and these results are given grouped as to

line intensity and line width in Table *Ib*; and again in Table *Ic* reduced to the basis mean rotation displacement 1·00, where the mean is determined by assigning equal weight to each line-intensity irrespective of the number of lines. Only 11 of the 19 lines 4 to 11, were measured on plates /.911 to /.917, and these results grouped as to intensity and width of lines are given in Tables II*b* to VII*b*; and in Tables II*c* and VII*c*, reduced to the basis, mean rotation displacement 1·00, as in I*c*. Under "Line" are given the wave-length, followed by the symbol of the element producing the line from Rowland's Tables; and under intensity (presumably that of the centre of the sun's disc) as given in Rowland's Tables, followed by measures of the intensities at limb /.917 (10); in the next column are given the half-widths of the lines at centre and limb from measures of /.917 (10). Then follow the half-measurements in km./sec. Means are taken for each line and intensity (horizontally) and for each proportion of blending (vertically). In taking the means, the first and tenth columns of these measures are, of course, omitted as they are not measures of blends.

TABLE Ia.

OBSERVATION.—Z554, (1 to 16) Spectra of Sun's Limbs at 0°, blended with spectrum of Centre of Disc.

MEASUREMENT.—Red right and red left, measurements: 4 settings middle strip, 2 settings each outside strip each way.

COMPUTATION.—Half-Line displacements and half-widths reduced to km./sec.

Line		Intensity		Half-Width		K =	0·50	0·83	0·74	0·62	0·54	Means	Residuals
		Centre	Limb	Centre	Limb	1·00						0·72	
5500·005,	Mn	1	0	2·2	3·5	1·690	1·503	1·344	1·535	1·120	0·866	1·302	- 0·019
14·563,	Ti	2	1-	1·9	2·9	1·560	1·763	1·534	1·663	1·178	0·885	1·353	·032
14·753,	Ti	2	1	2·0	3·3	1·717	1·537	1·327	1·453	0·980	0·878	1·275	·046
28·641, s,	Mg	8	7	4·6	4·3	1·681	1·704	1·4[illegible]		1·331	1·076	1·583	·02
44·157, s,	Fe	2	1	2·1	2·6	1·857	1·510	1·42[illegible]	[illegible]0	1·080	0·868	1·274	·37
60·434,	Fe	2	1	1·6	2·5	1·878	1·596	1·512	1·526	1·079	0·847	1·312	·010
62·933,	Fe	2	1	1·9	2·5	1·013	1·596	1·487	1·523	1·103	0·830	1·321	·001
78·946,	Ni	1	0	2·4	2·8	1·816	1·633	1·491	1·479	1·148	0·815	1·314	·007
82·198, s,	Ca	4	3	2·8	3·2	1·820	1·591	1·444	1·495	1·102	0·698	1·320	·005
90·343, s,	Ca	3	3-	2·8	3·0	1·042	1·770	1·510	1·503	1·297	0·907	1·417	·096
98·524, s,	Fe	1	0	2·5	3·0	1·070	1·504	1·482	1·470	0·072	0·823	1·305	- ·058
5501·505, s,	Ca	3	3-	2·8	2·7	1·753	1·638	1·514	1·420	1·251	0·827	1·330	·030
24·709, s,	Fe, V	4	3	4·0	3·4	1·673	1·625	1·440	1·420	1·173	1·012	1·339	·015
38·488,	Fe	5	2	2·5	2·5	1·817	1·585	1·466	1·562	1·085	0·804	1·288	·033
58·007,	V, -	2	1	2·8	3·1	1·857	1·050	1·405	1·507	1·012	1·028	1·334	·013
82·869, s,	Na	5	5	3·0	4·1	1·770	1·014	1·559	1·587	1·213	0·805	1·306	·045
84·710,	Si	3	2	2·6	2·8	1·842	1·004	1·359	1·446	1·031	0·668	1·222	·039
80·757,	Fe	3	2-	2·8	3·2	1·515	1·742	1·490	1·553	1·010	0·787	1·310	·011
5688·430, s,	Na	6	6	3·6	4·0	1·770	1·042	1·500	1·000	1·231	0·865	1·380	0·059
					Means	1·739	1·030	1·451	1·520	1·133	0·872	1·321	0·000
					Means	1·739	1·00	0·94	0·84	0·88	0·65	0·50	0·79

Table I*b*

OBSERVATION.—*Z*854, (1) to (16), See Table I*a*.

MEASUREMENT.—See Table I*a*.

COMPUTATION.—Displacements of Table I*a*, grouped as to Intensity and Width of Lines.

No. of Lines	Intensity		Half-Width		*K*	0·89	0·83	0·74	0·62	0·54	Means	Residuals
	Centre	Limb	Centre	Limb	1·00						0·72	
3	1	0	2·4	3·1	1·725	1·601	1·472	1·497	1·080	0·815	1·293	− 0·047
6	2	1	2·1	2·8	1·750	1·710	1·416	1·556	1·083	1·090	1·311	− ·029
5	3	2	2·7	2·9	1·714	1·668	1·451	1·515	1·135	0·709	1·313	− ·027
2	4	3	3·9	3·3	1·750	1·638	1·442	1·447	1·168	0·990	1·331	·009
1	5	5	3·9	4·1	1·779	1·614	1·559	1·587	1·213	0·859	1·366	+ ·020
1	6	6	3·6	4·0	1·779	1·642	1·660	1·600	1·231	0·865	1·380	+ ·040
1	8	7	4·6	4·3	1·681	1·704	1·410	1·393	1·331	1·076	1·383	+ 0·043
				Means	**1·740**	1·650	1·473	1·514	1·177	0·928	1·340	0·000

Table I*c*

Displacements of Table I*b* divided by 1·740.

No. of Lines	Intensity		Half-Width		*K* =	0·89	0·83	0·74	0·62	0·54	Means	Residuals
	Centre	Limb	Centre	Limb	1·00						0·72	
3	1	0	2·4	3·1	0·99	0·92	0·85	0·86	0·62	0·47	0·74	− 0·03
6	2	1	2·1	2·8	1·01	·98	·81	·89	·62	·63	·75 +	·02
4	3	2	2·7	2·9	0·99	·96	·84	·87	·65	·46	·76 −	− ·01 +
2	4	3	3·4	3·3	1·01	·93	·83	·83	·67	·57	·77	·00
1	5	5	3·7	4·1	1·02	·93	·90	·91	·70	·49	·79 −	+ ·02 −
1	6	6	3·6	4·0	1·02	·95	·90	·92	·71	·50	·79 +	+ ·02 +
1	8	7	4·6	4·3	0·97	0·98	0·81	0·80	0·77	0·62	0·80	+ 0·03
				Means	1·00	0·95	0·85	0·87	0·68	0·53	0·77	0·00

Table IIb.

Observation.—*Z*91:, (1) to (9), Spectra of sun's limbs at 75°, blended with spectrum at centre of disc.

Measurement.—Red right; 4 settings middle strip, 2 settings on each outside strip.

Computation.—Half-Displacements and half-widths of lines reduced to km. sec. Displacements grouped as to intensity and width.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	*R* = 1·00	0·89	0·79	0·69	0·58	0·51	0·43	0·33	0·24	Means 0·56	Residuals
2	1	0	2·4	2·9	0·397	0·117	0·226	0·253	0·190	0·103	0·160	−0·006	0·043	0·136	0·012
3	2	1 −	1·9	2·5	·411	·225	·126	·175	·122	·115	−·016	·047	·010	·101	·047
3	3	3 −	2·7	2·8	·395	·307	·167	·187	·121	·065	·068	·160	·067	·147	·001
2	4	3	3·4	3·3	·391	·324	·295	·297	·093	·139	·093	·061	·031	·167	+ ·019
1	8	7	4·6	4·3	0·275	0·332	0·367	0·359	0·240	0·067	0·111	0·029	0·002	0·188	+ 0·040
				Means	**0·374**	0·201	0·236	0·254	0·153	0·098	0·090	0·065	0·065	0·148	0·000

Table IIc.

Displacements of Table IIb. divided by 0·374.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	*R* = 1·00	0·89	0·79	0·69	0·58	0·51	0·42	0·33	0·24	Means 0·56	Residuals
2	1	0	2·4	2·9	1·06	0·31	0·60	0·03	0·51	0·28	0·43	−0·02	0·16	0·39	− 0·04
3	2	1 −	1·9	2·5	1·10	·60	·33	·47	·32	·31	−·04	·13	·03	·27	·13
3	3	3 −	2·7	2·8	1·06	·82	·45	·50	·32	·17	·18	·51	·18	·39	− ·01
2	4	3	3·4	3·3	1·05	·87	·74	·80	·25	·37	·25	·16	·08	·45	+ ·05
1	8	7	4·6	4·3	0·74	0·89	0·98	0·96	0·64	0·18	0·30	0·08	0·01	0·50	+ 0·10
				Means	1·00	0·70	0·63	0·68	0·41	0·26	0·24	0·17	0·08	0·40	0·00

TABLE III*b*.

OBSERVATION.—Z912, (1) to (9), Spectra of sun's limbs at 60°, blended with spectrum of centre of disc.

MEASUREMENT.—Red right; 4 settings middle strip, 2 settings on each outside strip.

COMPUTATION.—Half-Displacements and half-widths of lines reduced to km. sec. Displacements grouped as to intensity and width.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	R = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	Means 0·56	Residuals
2	1	0	2·4	2·9	0·582	0·574	0·491	0·203	0·218	0·110	0·074	0·097	−0·110	0·207	−0·042
3	2	1	1·9	2·5	·611	·608	·525	·258	·176	·064	·116	·037	−·011	·222	−·027
3	3	3−	2·7	2·8	·618	·602	·451	·353	·188	·138	·133	·000	·007	·232	·017
2	4	3	3·4	3·3	·510	·447	·532	·492	·085	·263	·060	·058	−·035	·232	−·017
1	8	7	4·6	4·3	0·501	0·615	0·503	0·607	0·426	0·292	0·181	0·109	0·000	0·350	+0·101
				Means	**0·565**	0·569	0·500	0·383	0·219	0·173	0·060	0·000	·033	0·249	0·000

TABLE III*c*.

Displacements of Table III*b*. divided by 0·565.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	R = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	Means 0·56	Residuals
2	1	0	2·4	2·9	1·03	1·02	0·8[illegible]	0·36	0·39	0·19	0·13	0·17	−0·19	0·37	−0·07
3	2	1−	1·9	2·5	1·08	1·08	[illegible]	·46	·31	·11	·21	·07	−·02	·39	−·05
3	3	3−	2·7	2·8	1·09	1·07	[illegible]	·62	·33	·24	·23	·00	−·01	·41	−·03
2	4	3	3·4	3·3	0·90	·79	·94	·87	·15	·47	·12	·01	−·06	·41	−·03
1	8	7	4·6	4·3	0·89	1·09	0·89	1·07	0·75	0·52	0·32	0·30	0·00	0·02	+0·18
				Means	1·00	1·01	0·89	0·68	0·39	0·31	0·20	0·11	−0·06	0·44	0·00

TABLE IV*b*.

OBSERVATION.—1913, (1) to (9), Spectra of sun's limbs at 45°, blended with spectrum from centre of disc.

MEASUREMENT.—Red right; 4 settings middle strip, 2 settings on each outside strip.

COMPUTATION.—Half-Displacements and half-widths of lines reduced to km./sec. Displacements grouped as to intensity and width.

No. of Lines	Intensity		Half-Width		R = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	Means 0·56	Residuals
	Centre	Limb	Centre	Limb											
2	1	0	2·4	2·9	1·078	0·821	0·622	0·373	0·343	0·254	0·113	0·025	0·016	0·315	0·092
3	2	1	1·9	2·5	1·120	·853	·554	·405	·441	·187	·145	·085	023	·337	·070
3	3	3	2·7	2·8	1·062	·982	·697	·418	·287	·290	·102	·132	·055	·382	·025
2	4	3	3·4	3·3	1·037	·896	·737	·535	·307	·320	·176	·111	·211	·412	·005
1	8	7	4·6	4·3	1·139	1·035	0·832	0·569	0·728	0·536	0·478	0·370	0·148	0·588	+ 0·181
				Means	1·088	0·917	0·688	0·460	0·421	0·317	0·221	0·130	0·091	0·407	0·000

TABLE IV*c*.

Displacements of Table IV*b*. divided by 1·088.

No. of Lines	Intensity		Half-Width		R 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	Means 0·56	Residuals
	Centre	Limb	Centre	Limb											
2	1	0	2·4	2·9	0·99	0·75	0·57	0·34	0·32	0·23	0·10	0·02	0·01	0·29	0·08
3	2	1	1·9	2·5	1·04	·78	·51	·37	·40	·17	·13	·08	·02	·31	·06
3	3	3	2·7	2·8	0·98	·90	·64	·38	·26	·27	·18	·12	·05	·35	·02
2	4	3	3·4	3·3	0·95	·82	·68	·49	·28	·29	·16	·10	·19	·38	·01
1	8	7	4·6	4·3	1·04	0·95	0·76	0·52	0·67	0·49	0·44	0·35	0·14	0·54	+ 0·17
				Means	1·00	0·84	0·63	0·42	0·30	0·29	0·20	0·12	0·08	0·37	0·00

Table V*b*.

Observation—Z912, (1) to (9), Spectra of sun's limbs at 30°, blended with spectrum of centre of disc.

Measurement – Red right; 4 settings middle strip, 2 settings on each outside strip.

Computation—Half-Displacements and half-widths of lines reduced to km. sec. Displacements grouped as to intensity and width.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	R = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	Means 0·56	Residuals
2	1	0	2·4	2·9	1·273	1·138	0·768	0·471	0·237	0·311	0·104	0·049	−0·040	0·379	−0·110
3	2	1−	1·9	2·5	1·389	1·190	·854	·531	·306	·196	·067	·158	−·030	·403	−·080
3	3	3−	2·7	2·8	1·367	1·197	·992	·572	·400	·267	·079	·192	−·062	·455	−·034
2	4	3	3·4	3·3	1·400	1·249	·871	·742	·460	·308	·158	·182	−·007	·495	+·006
1	8	7	4·6	4·3	1·306	1·239	1·058	0·955	0·728	0·586	0·513	0·386	+0·184	0·706	+0·217
				Means	**1·347**	1·201	0·909	0·654	0·426	0·334	0·184	0·193	0·000	0·489	0·000

Table V*c*.

Displacements of Table V*b*. divided by 1·347.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	R = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	Means 0·56	Residuals
2	1	0	2·4	2·9	0·95	0·84	0·57	0·35	0·18	0·23	0·08	0·04	0·33	0·28	0·08
3	2	1−	1·9	2·5	1·03	·88	·63	·39	·23	·15	·05	·12	−·02	·30	−·06
3	3	3−	2·7	2·8	1·01	·89	·74	·42	·30	·20	·06	·14	−·05	·34	−·02
2	4	3	3·4	3·3	1·04	·93	·65	·55	·34	·23	·12	·13	−·01	·37	+·01
1	8	7	4·6	4·3	0·97	0·92	0·78	0·71	0·54	0·44	0·38	0·29	+0·14	0·52	+0·16
				Means	1·00	0·89	0·67	0·49	0·32	0·25	0·14	0·14	0·30	0·30	0·00

TABLE VI*b*.

OBSERVATION—*Zq*15, (1) to (16), Spectra of sun's limbs at 15°, blended with spectrum from centre of disc.

MEASUREMENT—Red right; 4 settings middle strip, 2 settings on each outside strip.

COMPUTATION—Half-Displacements and half widths of lines reduced to km. sec. Displacements grouped as to intensity and width.

No. of Lines	Intensity		Half Width		*R* = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	1·00 and 0·00	Means 0·56	Residuals
	Centre	Limb	Centre	Limb												
2	1	0	2·4	2·9	1·729	1·582	1·673	0·670	0·509	0·061	0·051	−0·014	−0·027	1·026	0·474	− 0·081
3	2	1	1·9	2·5	1·866	1·405	1·114	531	·453	·142	·075	·047	− ·083	·927	·461	− ·094
3	3	3	2·7	2·8	1·764	1·640	1·145	·733	·547	·208	·067	− ·033	− ·101	·880	526	− ·029
(2)	4	3	3·4	3·3	1·742	(1·280)	1·280)	(·841	·557	·406	·097	·010	− ·001	·898	(·559	+ ·004
1	8	7	4·6	4·3	1·773	1·802	1·590	0·970	0·686	0·570	0·292	0·173	−0·040	0·962	0·755	+ 0·200
				Means	**1·775**	1·542	1·240	0·749	0·630	0·277	0·116	0·037	−0·050	0·050	0·555	0·000

TABLE VI*c*.

Displacements of Table VI*b*, divided by 1·775.

No. of Lines	Intensity		Half Width		*R* 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	1·00 and 0·00	Means 0·56	Residuals
	Centre	Limb	Centre	Limb												
2	1	0	2·4	2·9	0·97	0·89	0·93	0·58	0·23	0·03	0·03	− 0·01	− 0·02	0·58	0·27	0·04
3	2	1	1·9	2·5	1·05		·63	·30	·26	·08	·04	·03	·05	·52	·26	− ·05
3	3	3	2·7	2·8	0·99		·65	41	·31	·12	·04	− ·02	·06	·50	·30	·01
(2)	4	3	(3·4)	(3·3)	(0·98)	2)	(·72)	(·47)	·31	·23	·05	·01	·00	·51	(·32)	+ ·01
1	8	7	4·0	4·3	1·00	1·02	0·93	0·55	0·39	0·32	0·16	0·10	0·02	0·54	0·43	+ 0·12
				Means	1·00	0·87	0·70	0·42	0·35	0·16	0·07	0·02	− 0·03	0·53	0·31	0·00

TABLE VII*b*.

OBSERVATION--Z917, (1) to (10), Spectra of sun's limbs at 0°, blended with spectrum of centre of disc.

MEASUREMENT--Red right; 4 settings middle strip, 2 settings on each outside strip.

COMPUTATION--Half-Displacements and half-widths of lines reduced to km. sec. Displacements grouped as to intensity and width.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	R = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	1·00 and 0·00	Means 0·56	Residuals
2	1	0	2·4	2·9	1·776	1·414	1·115	0·493	0·529	0·205	0·436	0·085	0·063	0·897	0·543	- 0·080
3	2	1 -	1·9	2·5	1·725	1·636	1·071	·600	·505	·074	·269	·000	·114	·949	·534	- ·089
3	3	3 -	2·7	2·8	1·591	1·413	1·030	·682	·647	·115	·385	·093	·119	·937	·561	·092
2	4	5	3·4	3·3	1·926	1·686	1·148	·792	·663	·300	·459	·071	·144	·939	·658	+ ·035
1	8	7	4·6	4·3	1·583	1·583	1·538	0·943	1·062	0·417	0·620	0·157	0·119	0·786	0·817	+ 0·194
				Means	**1·740**	1·546	1·180	0·702	0·681	0·222	0·434	0·101	0·112	0·901	0·023	0·000

TABLE VII*c*.

Displacements of Table VII*b*. divided by 1·740.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	R = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	1·00 and 0·00	Means 0·56	Residuals
2	1	0	2·4	2·9	1·02	0·81	0·64	0·28	0·30	0·12	0·25	0·05	0·04	0·52	0·31	- 0·05
3	2	1 -	1·9	2·5	0·99	·94	·62	·34	·29	·04	·15	·00	·07	·55	·30	- ·07
3	3	3 -	2·7	2·8	0·97	·81	·59	·39	·37	·06	·22	·05	·07	·54	·32	- ·04
2	4	3	3·4	3·3	1·11	·97	·66	·45	·38	·17	·26	·04	·08	·54	·38	+ ·02
1	8	7	4·6	4·3	0·91	0·91	0·88	0·54	0·61	0·24	0·36	0·15	0·07	0·45	0·47	+ 0·11
				Means	1·00	0·89	0·68	0·40	0·39	0·13	0·25	0·00	0·00	0·52	0·30	0·00

TABLE VIII*b*.

Summary of Plates *L*911 to *L*917, means grouped as to intensity and width of lines.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	K = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	Means 0·56	Residuals
2	1	0	2·4	2·9	1·139	0·939	0·716	0·411	0·321	0·174	0·156	0·033	− 0·009	0·343	− 0·068
3	2	1 −	1·9	2·5	1·188	0·986	·707	·417	·334	·130	·109	·062	·004	·344	− ·028
3	3	3 −	2·7	2·8	1·150	1·024	·747	·491	·305	·151	·154	·096	·012	·384	− ·009
2	4	3	3·4	3·3	1·168	0·980	·811	·617	·361	·289	·175	·074	·061	·421	+ ·155
1	8	7	4·6	4·3	1·181	1·101	0·981	0·734	0·645	0·411	0·366	0·232	0·069	0·507	+ 0·086
				Means	1·165	1·009	0·792	0·534	0·405	0·237	0·192	0·099	0·027	0·412	0·000

TABLE VIII*c*.

Mean displacements of Table VIII*b*, divided by 1·165.

No. of Lines	Intensity Centre	Intensity Limb	Half-Width Centre	Half-Width Limb	K = 1·00	0·89	0·79	0·69	0·60	0·51	0·42	0·33	0·24	Means 0·56	Residuals
2	1	0	2·4	2·9	0·98	0·81	0·61 +	0·35	0·28	0·15	0·13	0·03	0·01	0·29	− 0·06
3	2	1 −	1·9	2·5	1·02	·85	·61 −	·36	·29	·11	·09	·05	·00	·29	− 0·06
3	3	3 −	2·7	2·8	0·99	·88	·64	·42	·31	·16	·13	·08	·01	·33	·02
2	4	3	3·4	3·3	1·00	·84	·70	·53	·31	·25	·15	·09	·05	·36	+ ·01
1	8	7	4·6	4·3	1·01	0·95	0·84	0·63	0·55	0·35	0·31	0·20	0·09	0·49	+ 0·14
				Means	1·00	0·86	0·68	0·40	0·35	0·20	0·16	0·08	0·02	0·35	0·00

Table IX.

Plates	Rotation Displacements	Proportionate Rotation Displacements for Intensities 1	2	3	4	8	Mean
Zo11	0·374	0·36	0·27	0·39	0·45	0·50	0·40
Zo12	0·505	0·37	0·30	0·41	0·41	0·02	0·44
Zo13	1·088	0·20	0·31	0·35	0·38	0·54	0·37
Zo14	1·347	0·28	0·30	0·34	0·37	0·52	0·30
Zo15	1·775	0·27	0·26	0·30	(0·32)	0·43	0·32
Zo17	1·740	0·31	0·30	0·32	0·38	0·47	0·30
							0·37

Table X.

l	c	Intensity 1 d	Intensity 1 k	Intensity 2 d	Intensity 2 k	Intensity 3 d	Intensity 3 k	Intensity 4 d	Intensity 4 k	Intensity 8 d	Intensity 8 k	Mean d	Mean k
45	3·5	0·81	1·0	0·85	1·3	0·88	1·1	0·84	1·4	0·05	0·7	0·86	1·2
40	7·0	·01	1·0	·01	1·0	·04	1·7	·70	1·4	·84	0·8	·68	1·5
35	10·5	·35	3·1	·30	3·0	·42	2·4	·53	1·7	·03	1·2	·46	2·1
30	14·0	·28	3·0	·20	2·0	·31	2·6	·31	2·6	·55	1·2	·35	2·2
25	17·5	·15	4·5	·11	6·3	·16	4·2	·25	2·5	·35	1·7	·20	3·3
20	21·0	·13	4·0	·00	5·8	·13	4·0	·15	3·4	·31	1·5	·16	3·2
15	24·5	·03	13·1	·05	7·8	·08	4·8	·00	6·5	·20	1·8	·08	4·8
10	28·0	0·01		0·00		0·01	27	0·05	5·3	0·06	3·2	0·02	13·5
Interpolated		0·50	**2·4**	0·50	**2·3**	0·50	**2·0**	0·50	**1·8**	0·50	**1·3**	0·50	**2·0**

Table XI.

l	c	Intensity 1 d	Intensity 1 R_1	Intensity 2 d	Intensity 2 R_1	Intensity 3 d	Intensity 3 R_1	Intensity 4 d	Intensity 4 R_1	Intensity 8 d	Intensity 8 R_1	Mean d	Mean R_1
45	3·5	0·81	0·71	0·85	0·72	0·88	0·70	0·84	0·78	0·05	0·83	0·86	0·76
40	7·0	·01	·54	·01	·55	·04	·00	·70	·03	·84	·72	·68	·60
35	10·5	·35	·42	·30	·44	·42	·48	·53	·51	·03	·01	·46	·48
30	14·0	·28	·33	·20	·35	·31	·30	·31	·42	·55	·52	·35	·39
25	17·5	·15	·27	·11	·27	·16	·31	·25	·34	·35	·43	·20	·31
20	21·0	·13	·21	·09	·22	·13	·24	·15	·27	·31	·35	·16	·24
15	24·5	·03	·10	·05	·10	·08	·18	·06	·20	·20	·27	·08	·18
10	28·0	0·01	0·11	0·00	0·11	0·01	0·13	0·05	0·14	0·06	0·10	0·02	0·13

A glance at Table I*a*. suffices to show that the measured displacements of the blended spectrum lines vary greatly from line to line, being greater as the intensity or width of the line increases. This is shown more positively when the lines are grouped as to intensity and width in Table I*b*. and reduced to the unity basis in Table I*c*., where also a comparison is readily made with the values of R.

Plates *L*911 to *L*917 cover a considerable range of displacements and of proportions of blending. The measurements of these plates — displacements grouped as to intensity and width, Tables II*b*. to VII*b*. — show the same dependence of the measures on intensity. Tables II*c*. to VII*c*. reduced to the basis, rotation displacement = 1·00, are more readily compared with one another. Summarizing the means of the different plates, Table IX., it is seen that there is very little dependence of the proportionate displacements on the initial (rotation) displacement: possibly a slight tendency to smaller proportionate displacements as the initial displacement is increased. This absence of variation of proportionate displacement with initial displacement is, no doubt, due to the fact that the greatest displacement, 2 × 1·78 km./sec., is only about half of the average width of lines, 2 × 3 km./sec. Increasing the initial displacements further, (which is, of course, impossible in this case, being restricted by the speed of the sun's rotation), would undoubtedly show greater effect on the measured proportionate displacements. Width of line would then become a more important factor. Since the proportionate values of the measurements do not depend on the initial displacement, the summary of the means of Plates *L*911 to *L*917, for the various proportions of blending of centre and limb spectra, Table VIII*b*., and their proportionate values, Table VIII*c*., may be taken as representative of all measures in the discussion which follows.

The values of Table VIII*c*. are plotted in Figure 1, proportionate displacements, d, plotted vertically and values of R, (*i.e.*, ratio of density of continuous spectrum of limb exposure to density of the continuous spectrum in total exposure), plotted

horizontally. Now an obvious reason to account for the different values of d for various lines is the fact that the ratio of intensity of the centre lines to the intensity of the limb lines varies for different lines. We would expect that if spectra of equal intens-

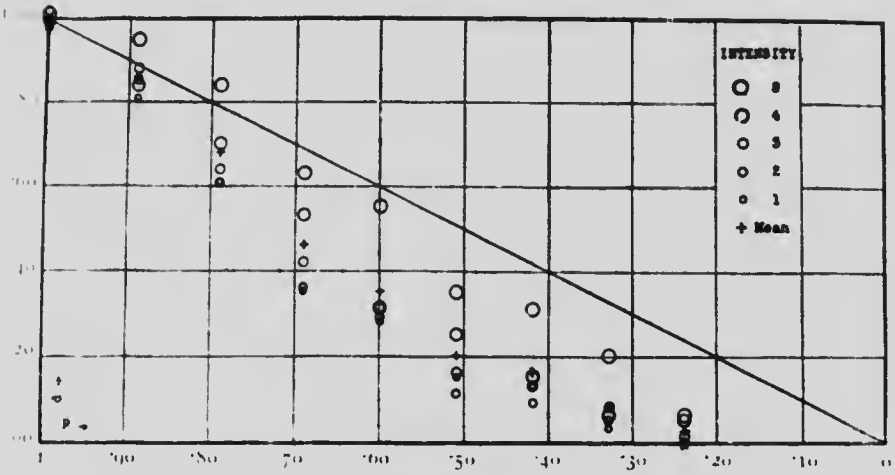


FIGURE 1.

ity — *lines* not *continuous* spectrum — were blended, the value of d would be 0·50; especially as errors of interpretation and photographic effect would be annulled in its measurement. In computing R we have,

$$R = c_1^{0\cdot7} \quad (c_1 + c)^{0\cdot7}, \text{ where } l^{0\cdot7} = 1\cdot8\, c_1^{0\cdot7},$$

l and c being the times of exposure on limb and then centre, and 1·8 is the ratio of intensity of limb continuous spectrum to centre continuous spectrum. In computing R_1 for any line, however,

$$R_1 = c_1^{0\cdot7} \quad (c_1 + c)^{0\cdot7}, \text{ where } l^{0\cdot7} = 1\cdot8\, k\, c_1^{0\cdot7},$$

where k = ratio of intensity of centre line to corresponding limb line. Consequently, assuming that $R_1 = d$ for each line, k can be found. These values of k are given in Table X. The values of k are seen to vary considerably for the different degrees of blending, pointing to a cause other than the difference in intens-

ity of the lines in centre and limb. However, it seems safe to assume that this cause is inoperative for values of d 0·50 in each case; so that we may take the values of k interpolated for d 0·50 as representing the true ratio of centre line to limb line. Rough visual determinations agree with these values of k. Using these values of k the values of R_1, Table XI., are found. Now plotting d and R_1, Figure 2, we see that the curve of observations, nearly the same for each line, swings symmetrically above

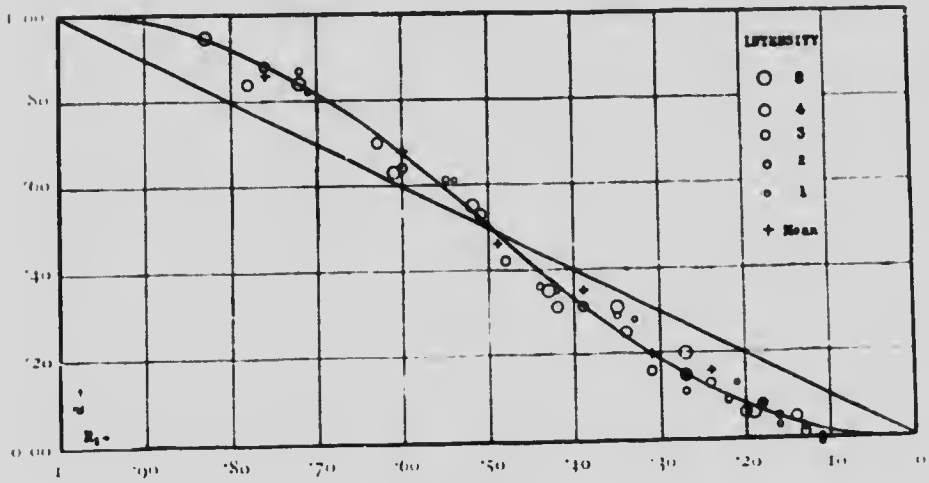


FIGURE 2.

and below the line $d = R_1$. The measurements thus exhibit some tendency common to all lines, possibly due to photographic action but more probably due to interpretation of the blends, *i. e.*, when strong and weak spectra are blended one's measurements tend to give proportionately greater weight to the stronger spectrum. This is in agreement with my measures of the blending of sky spectrum with sun rotation spectra in which the lower proportions of blending showed no appreciable effect of the sky spectrum.

The results found above are applicable to the interpretation of certain peculiarities found in the spectroscopic study of double

stars, the comparison of velocities of stars of different type, and other astrophysical problems; but I shall not discuss these points here. The results are applicable directly to the problem of the determination of the rate of the sun's rotation; in fact the above work was undertaken primarily in the hope that it would offer an explanation of the difference in the rate of the sun's rotation as determined from different spectrum lines (as announced by Adams for his determinations of 1906-1908), and possibly of the greater polar retardation from the spectroscopic observations than from the spots and faculæ. Adams' results have recently been verified by himself and St John at Mt. Wilson in a manner that leaves little room for doubt as to thier accuracy, thongh for the period 1911-1913 several other observers found little or no trace of the effect. The assumption of blended spectra during the time of sun-spots and an absence of the effect when the spots are absent offers an explanation of the above observations, but the point will be discussed soon in a separate paper.

The main conclusions of the above work are:

In the measurements of photographs of blended spectra the stronger spectrum asserts itself out of proportion to the relative intensities of the lines measured, the effect being more pronounced the greater the difference in the intensities of the components of the blends.

When spectra, in which the lines have different character and are displaced by amounts ranging up to half the widths of the lines in question, are blended, the measurements of the resulting lines vary from line to line as the relative intensities vary. In the case of blending the sun's limb (lines displaced by rotation) and centre (lines not displaced) spectra, since the relative intensities of lines progresses fairly regularly with intensity (*i. e.*, level in the sun) the measured displacements of the blends progress regularly. In other words, lines of different intensity show different velocities of rotation, the strong lines showing progressively greater values than the weak lines; and since this very effect has been found by some observers in the determination of the sun's rate of rotation it is suggested that at

the time of their observations the limb spectra were blended with spectra in which the lines were less displaced or not displaced at all, such as a strong sky spectrum or spectrum from indepe ently moving matter outside the sun or matter just freshly fall into the sun and not sharing completely its rotation.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
February, 1916.