Application of the Hartmann method for the determination of the secondary spectrum of an objective

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TABLE 2.

plate no.	sidereal time Jhbg	position of telescope	Δ α cos δ: number of images measured, film	glass	mean error of single image	mean error of mean	Δ δ: number of images measured, film	glass	mean error of single image	mean error of mean	character of images measured	effective Δ m	number of single settings	measured by
1	13h 26m	W	12	13	± ″·106	± ″·030	12	13	± ″·068	± ″·020	4	— 1m·02	200	Hzg
			15	16	83	21	17	18	98	24	3	·39	198	Hzg
2	14 24	W	49	47	99	14	50	49	126	18	3	·39	585	φ
			46	56	97	14	49	54	95	14	3	·39	615	Hzg
3	15 42	E	15	15	99	26	14	14	92	25	3	·39	174	φ
4	16 20	E	26	32	80	15	34	30	90	16	3	·39	366	φ
24	14 11	W	116	116	68	6	116	116	74	7	3	·39	1392	φ
30	13 48	W	111	115	80	8	111	111	83	8	3	·39	1344	B
			116	99	77	8	106	106	83	8	3	·39	1281	Hzg
38	16 50	E	140	139	117	10	116	106	99	9	3	·39	1503	φ
			124	116	91	9	123	127	92	8	3	·39	1470	Hzg
45	15 17	E	130	131	79	7	135	141	89	8	3	·39	1611	B
			135	140	88	8	127	130	91	8	3	·39	1596	Hzg
50	15 42	E	47	44	61	9	47	48	78	11	3	·39	558	Hzg
57	15 38	E	74	76	67	8	76	72	62	7	3	·39	894	,,
255	12 45	W	50	46	93	14	46	40	80	12	3	·39	546	,,
290	14 57	E	70	73	61	8	76	75	69	8	3	·39	882	,,
319	13 32	W	46	41	75	12	41	46	87	13	4	·02	696	,,
381	13 31	W	30	28	56	11	27	27	59	12	4	·02	448	Hzg
			28	35	65	12	39	38	77	13	4	·02	560	B
399	13 13	W	126	113	48	5	129	118	54	5	4	·02	1944	Hzg
434	14 56	E	221	224	40	3	223	221	51	4	4	·02	3556	,,
449	14 22	W	105	88	68	7	70	63	66	8	4	·02	1304	,,
			124	124	53	5	122	122	52	5	3	— ·65	1476	,,
460	14 59	E	140	140	58	5	140	134	62	6	4	·02	2216	,,
510	15 58	E	75	78	51	6	78	82	57	7	4	·02	1252	,,
515	15 25	E	104	92	55	6	74	100	59	7	4	·02	1480	,,
518	15 25	E	64	60	63	8	61	58	63	8	4	·02	972	,,
519	16 10	E	53	45	53	8	47	43	64	10	4	·02	752	,,
537	14 20	W	69	51	61	8	64	52	69	9	4	·02	944	,,
542	13 4	W	96	103	51	5	79	91	65	7	4	·02	1476	,,

Application of the Hartmann-method for the determination of the secondary spectrum of an objective, by *Ejnar Hertzsprung*.

The two triplets, the secondary spectra of which are investigated in the present note, have a diameter of 40 cm and a focal length of 229 cm. They have been made by Sir HOWARD GRUBB, PARSONS & Co., to whom I am obliged for providing me with the necessary plates, which have been taken in the workshop at Newcastle on Tyne.

The arrangement used is schematically shown in Figure 1, the light thus being made to pass the optical system twice. In front of the objective was placed a diaphragm containing a row of seven holes, each with a diameter of 25 mm. The distances of these holes from the centre were 0, ± 6, ± 11 and ± 16 cm.

Two pairs of plates were taken with each of the two objectives, one with the heliumarc as a light-source and one with the mercuryarc.

A reproduction of the intra- and extrafocal images, obtained in this way, is shown in Figure 2, the difference in distance from the objective between the intra- and extrafocal position of the plate being 10 cm. The approximate energy-intensity of the lines

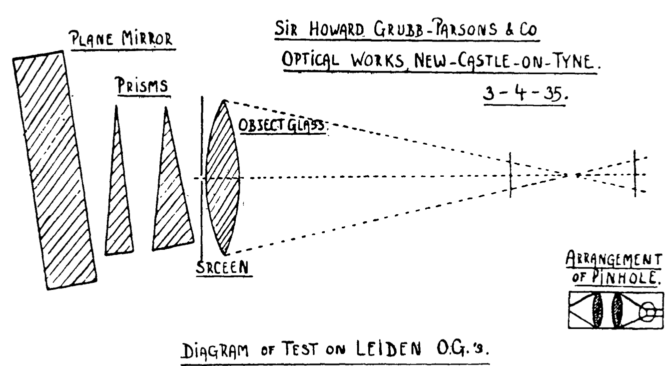
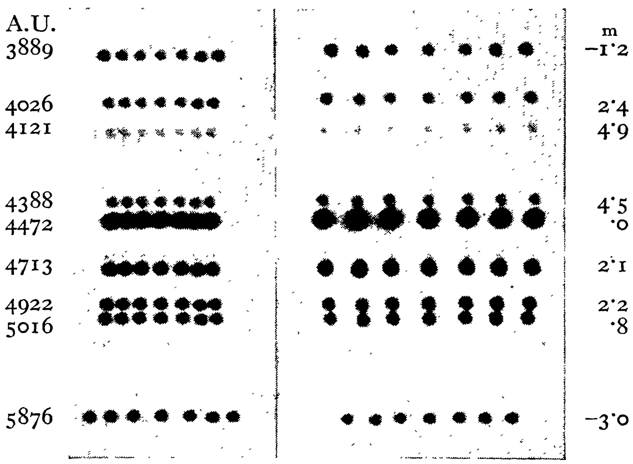


Figure 1.

shown on Figure 2 are given in the scale of stellar magnitudes, using the magnitude of the line at 4472 A as an arbitrary zeropoint, and taken from the Utrecht-dissertation of D. BURGER. Their apparent intensities on the diagram are influenced by the spectral sensitiveness of the ordinary plate used and by the absorption of the objectives and prisms at the shorter wavelengths, whereby it should be taken into account that the light has passed the optical system twice and in addition has been reflected from silver.

The results of the measurements are given in Table 1, where r is the distance from the axis of the objective to the hole in the diaphragm, and d_i and d_e the distances measured on the plate between the intra- and extrafocal images respectively.

The effective wavelengths, adopted for conglomerates of lines, are rather arbitrary but are supposed to be sufficiently accurate.



intrafocal Figure 2. *extrafocal*
Enlargement 3 times

The results are given separately for the two objectives „A" and „B".

Assuming that the secondary spectrum is practically represented by the formula:

$$\frac{f - f_{\min}}{f_{\min}} = b\left(c - \frac{1}{\lambda - \cdot 2}\right)^2,$$

where f is the focal length corresponding to the wavelength λ, measured in μ. The constant b indicates the extension of the secondary spectrum, while the constant c determines the wavelength, at which the focal length is minimum.

Consequently we may write:

$$d_e - d_i = A + B\,\frac{1}{\lambda - \cdot 2} + C\,\frac{1}{(\lambda - \cdot 2)^2}.$$

The constants A, B and C have in each case been determined according to least squares. The values thus found are given in Table 2 together with the corresponding values of the wavelength, at which the focal length is minimum and of the constant b in the above formula.

In the mean b is thus found to be ·00115, which is quite normal for a triplet.

The focal length has its minimum value in the neighbourhood of the G-line, which is entirely satisfactory for ordinary photographic purposes.

The wavelength of minimum focal length increases slightly with the radius of the zone, but not more than would be expected.

TABLE 1.

„A" λ	$\frac{1}{\lambda - \cdot 2}$	r = 6 cm					r = 11cm					r = 16cm				
		d_i	d_e	d_e+d_i	d_e-d_i	$O-C$	d_i	d_e	d_e+d_i	d_e-d_i	$O-C$	d_i	d_e	d_e+d_i	d_e-d_i	$O-C$
μ		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
·38886	5·2949	1·993	3·205	5·198	1·212	+ ·019	3·641	5·926	9·567	2·285	+ ·020	5·347	8·546	13·893	3·199	— ·005
·40264	4·9349	1·857	3·375	5·232	1·518	+ 16	3·360	6·218	9·579	2·858	— 4	4·884	9·021	13·905	4·136	— 12
·41208	4·7152	1·822	3·395	5·217	1·573	— 48	3·247	6·315	9·562	3·068	— 30	4·638	9·208	13·846	4·570	+ 35
·43879	4·1878	1·784	3·427	5·211	1·644	— 49	3·133	6·395	9·528	3·262	— 4	4·473	9·358	13·831	4·885	+ 11
·44715	4·0461	1·745	3·438	5·183	1·693	+ 33	3·184	6·390	9·574	3·206	— 10	4·574	9·362	13·936	4·788	— 36
·47132	3·6857	1·865	3·363	5·228	1·498	+ 20	3·333	6·264	9·597	2·931	+ 25	4·761	9·158	13·919	4·397	— 30
·49219	3·4224	1·975	3·253	5·227	1·278	+ 22	3·514	6·033	9·547	2·520	+ 5	4·996	8·908	13·903	3·912	+ 21
·50157	3·3160	2·025	3·172	5·197	1·147	+ 2	3·625	5·950	9·576	2·325	+ 9	5·131	8·770	13·901	3·639	+ 22
·58756	2·5802	2·581	2·603	5·184	·022	— 15	4·618	4·930	9·548	·311	— 12	6·537	7·322	13·858	·785	— 7
				5·209					9·564					13·888		
·40466	4·8863	2·342	2·927	5·269	·585	— ·017	4·319	5·303	9·622	·984	— ·008	6·301	7·708	14·009	1·407	+ ·013
·40778	4·8127	2·302	2·955	5·257	·653	+ 15	4·244	5·344	9·588	1·100	+ 24	6·227	7·762	13·989	1·535	— 6
·43502	4·2550	2·252	2·994	5·246	·742	+ 9	4·150	5·474	9·624	1·324	— 33	5·964	8·055	14·019	2·091	— 18
·49161	3·4293	2·480	2·746	5·226	·266	— 13	4·509	5·150	9·659	·641	+ 23	6·381	7·574	13·955	1·193	+ 19
·54607	2·8896	2·807	2·412	5·219	− ·395	+ 6	5·089	4·488	9·577	− ·601	+ 7	7·271	6·684	13·955	− ·587	— 5
·57801	2·6454	3·022	2·214	5·236	− ·808	0	5·470	4·101	9·571	−1·369	— 13	7·816	6·139	13·955	−1·677	— 3
				5·242					9·607					13·980		