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COMMUNICATIONS FROM THE OBSERVATORY AT LEIDEN

Discussion on personal errors in photographic measures of double stars,

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The errors met with in photographic measures of double stars may be classified as follows, though a precise discrimination between the various kinds cannot be made:

A. Errors inherent in the photographic image,
B. Errors of measurement,
C. Personal errors of interpretation of the image.

Each of these types of errors may be divided into a systematic and an accidental part.

The squares of the mean accidental errors of these three kinds are designated respectively by I (image), M (measurement) and P (person).

The separation between I and P is naturally conventional and may vary from one person to another according to the way in which the centre of the image is chosen. E.g. one person may point on the blackest spot he can find in the image even if it is lying eccentrically, while another will try to cut the whole image into two equal parts.

It is well known that marked personal errors are shown by ordinary visual measures of double stars and these errors soon put a limit to the number of nights in which it pays to have a double star visually measured by a single observer. This number of nights is about three.

The question to which extent personal errors also exist in photographic measures of double stars is of equal importance as the systematic character of such errors will determine the maximum accuracy which can be reached by a single person. Otherwise than in the case of visual measures the material for obtaining a judgement of personal errors in photographic measures is very scarce. The same series of photographs of double stars has rarely been measured by more than one person. Only two notable cases of this kind are known, viz. the measures 1° of a number of Potsdam plates of ξ UMa by W. H. VAN DEN BOS and the writer (*Mém. Acad. Roy. de Danemark, section des sciences*, 8e série, t. XII, no. 2; 1928) and 2° of several other plates of 6 different double stars by K. AA. STRÅND and the writer (*Ann. Sterrewacht te Leiden*, XVIII, part 2). As only three persons are concerned with the measures just mentioned they throw but little light on the question of systematic personal errors. For this reason the writer thought it desirable to have a plate, carrying several exposures of a double star, measured by a number of persons sufficiently large to obtain an idea of the general variation of the systematic error from one individual to another.

The present investigation is based on a single plate, no. 271, of Antares taken with the visual refractor at Johannesburg diaphragmed to 30 cm aperture. The focal length is 1070 cm and the scale on the plate 1 mm = 18″·909. The plate was taken under excellent atmospheric conditions when the object was near to the zenith. A coarse grating, which gave diffraction images of the brighter component nearly equal to the central image of the 4^m fainter companion, was placed in front of the objective. The position angle of the wires of the grating was 81°. The distance between the spectra of the first order and the central image was 259 μ or 4″·90. The constant of the grating, $d + l$, was 23·29 mm and the effective wavelength of the images ·553 μ. The diameter of the images measured is about 45 μ and of the not measured central image of the brighter component about 147 μ. The exposure time was generally about ·4 seconds and was chosen as short as feasible in order to avoid systematic photographic errors in distance of this close pair. The distance on the plate between the two stars is 159 μ and the corresponding clear space between them 159 − $\frac{1}{2}$(45 + 147) = 63 μ. Systematic plate errors are therefore hardly to be expected.

The plate carries two rows of respectively 31 and 35 exposures separated by a trail of Antares for the direction of the daily motion. The last image, no. 66, was for identification purposes exposed distinctly longer than the rest. The plate was taken 1931 April 24th round 17^h5^m sid. time Johannesburg or in the conventional counting of years 1931·311. The temperature was 12° C and the focal reading 48·6 mm. A

TABLE 1.

	date	n_f	n_g	$\Delta\alpha \cos\delta$	Δ	2M+I	n_f	n_g	$\Delta\delta$	Δ	2M+I
				μ	μ	μ^2			μ	μ	μ^2
E. HERTZSPRUNG	1932·38	44	50	158·84	— ·04	10·1	53	50	13·32	·04	11·6
G. P. KUIPER	·39	51	56	8·80	— ·09	7·3	57	52	3·16	— ·11	8·5
P. TH. OOSTERHOFF	·39	51	54	8·28	— ·60	9·0	55	58	2·87	— ·40	10·2
W. H. VAN DEN BOS	35·47	63	63	9·04	·16	7·5	65	64	3·00	— ·27	7·1
D. REUYL	·87	46	45	9·35	·46	8·6	44	39	2·85	— ·43	5·5
M. SCHWARZSCHILD	·94	64	64	8·46	— ·42	11·4	63	63	3·37	·10	10·0
K. AA. STRAND	·97	58	59	8·04	— ·84	11·6	60	60	2·27	—1·00	12·6
J. MERGENTALER	36·44	54	(53)	(8·70)	(— ·18)		57	54	3·68	·41	9·2
F. DE HAAS	·50	61	60	8·93	·04	15·2	62	61	3·45	·18	16·4
MISS H. A. KLUYVER	·64	63	63	8·61	— ·27	20·4	60	60	2·73	— ·54	11·3
J. M. ABRAMS	·65	52	54	9·51	·63	10·1	61	56	2·51	— ·76	13·1
J. DE KORT	·66	46	57	9·42	·54	15·5	51	55	3·40	·13	15·4
D. GAYKEMA	·71	64	62	9·41	·53	9·7	62	61	3·14	— ·14	6·8
A. VAN HOOF	·73	45	48	9·91	1·02	6·0	50	49	3·53	·26	6·5
J. ZEEMAN	·74	52	52	9·45	·57	8·1	48	53	4·06	·79	7·6
C. J. KOOREMAN	·74	46	52	9·79	·91	6·8	51	53	3·49	·21	5·8
A. J. WESSELINK	·75	46	33	9·22	·34	7·1	36	35	3·55	·28	7·2
L. PLAUT	·75	65	65	8·63	— ·25	8·8	65	65	2·42	— ·86	7·9
A. DE SITTER	·75	55	51	9·05	·17	8·6	56	55	3·09	— ·18	10·1
G. VAN HERK	·76	65	65	9·04	·16	13·6	65	65	2·91	— ·36	10·7
R. PRAGER	·77	63	65	8·90	·02	4·3	64	63	3·62	·35	9·2
J. H. OORT	37·11	50	48	8·78	— ·10	4·9	45	42	3·43	·16	5·9
C. H. HINS	·27	58	47	9·48	·60	8·6	55	53	4·27	1·00	8·0
A. BLAAUW	·28	64	64	8·86	— ·02	14·1	65	65	3·29	·02	10·9
J. UITTERDYK	·29	58	58	8·81	— ·08	7·3	60	58	3·36	·09	8·5
W. CHR. MARTIN	·30	62	64	8·45	— ·44	8·3	63	64	2·80	— ·47	6·1
G. PELS	·31	65	65	8·21	— ·67	11·8	65	65	3·22	— ·05	12·7
C. SANDERS	·34	62	64	8·52	— ·37	13·3	64	64	3·41	·13	10·4
L. BINNENDYK	·37	65	65	8·54	— ·34	11·3	65	65	3·61	·34	10·6
H. KLEIBRINK	·39	62	64	8·53	— ·35	14·9	64	64	2·72	— ·56	11·6
H. VAN GENT	·44	60	62	9·29	·41	8·3	63	63	3·31	·03	7·7
J. G. FERWERDA	·53	52	52	9·06	·17	10·4	52	53	3·67	·40	9·5
R. ROELOFS	·53	64	65	8·88	— ·00	10·2	64	65	3·53	·26	10·9
F. NISOLI	38·41	64	64	9·07	·19	10·3	64	65	2·52	— ·75	10·0
J. SCHILT	·51	44	44	8·19	— ·70	11·9	43	40	3·33	·06	8·1
W. J. LUYTEN	·53	65	65	8·15	— ·74	9·5	65	65	3·30	·02	10·7
H. M. JEFFERS	·73	42	44	9·90	1·01	7·0	47	41	3·97	·69	3·9
J. M. KRIEST	·84	65	65	9·27	·39	19·4	65	65	2·93	— ·34	9·9
H. W. R. KRAUSS	·86	63	55	8·22	— ·66	7·6	63	63	3·80	·53	10·0
G. V. SIMONOV	39·32	64	59	8·93	·04	13·0	62	62	3·98	·71	16·4
M. RUDKJØBING	·45	66	66	8·16	— ·73	19·4	66	66	2·97	— ·30	13·4
A. D. THACKERAY	·49	53	60	8·41	— ·47	9·0	58	51	3·24	— ·03	8·3
P. SÉMIROT	·62	64	65	8·55	— ·34	10·8	65	65	3·03	— ·24	11·0
W. H. DIRKS	·78	57	65	8·84	— ·04	13·1	62	61	3·77	·50	8·3
D. BENNINK	40·03	59	65	9·08	·19	16·1	57	63	3·37	·09	9·3

yellow screen was used in combination with an Eisenberger erythrosine plate.

This plate was measured by 45 different persons. The main results are given in Tables 1 and 2 in the form of mean values respectively for each person and for each image. The measurement was carried out separately in the two rectangular co-ordinates $\Delta\alpha \cos\delta$ and $\Delta\delta$ and made in Leiden with the Toepfer machine of the Danish Carlsberg Foundation. The plate was moved micrometrically in one direction and measured both with the film turned toward the microscope and through the glass, the plate being turned 180° round an axis parallel to the pointing wire. In this way certain errors of measurement are eliminated.

In Table 1 mean results obtained by each person are given in chronological order of measurement. The choice of the images to be used was left to the person who had to do the measures. The images measured in the two positions of the plate were not always the same so that images of inferior quality automatically obtained half weight.

Between the two measures of $\Delta\alpha \cos\delta$ made by MERGENTALER the plate was erroneously turned round an axis parallel to the trail. These measures have therefore been used only partially. They are placed in parentheses in Table 1.

All the readings were made in microns.

In Table 2 the results are given separately for each image. It includes all measures made, also those which were rejected in Table 1. The total number of single settings used is 31332.

The relative weights given in Table 2 are rather arbitrary. They are mainly based on the indication

TABLE 2.

no. of image	number of exposures measured n_2	n_1	$2n_2+n_1$	$\Delta\alpha \cos\delta$	rel. p	Δ	M+P	M	number of exposures measured n_2	n_1	$2n_2+n_1$	$\Delta\delta$	rel. p	Δ	M+P	M
				μ		μ	μ^2	μ^2				μ		μ	μ^2	μ^2
1	29	6	64	158·88	5	·00	8·29	8·98	29	10	68	9·70	6	−3·71	9·39	4·62
2	31	7	69	55·40	6	−3·48	4·42	3·99	33	7	73	9·25	7	−4·16	3·20	3·74
3	38	6	82	63·59	10	4·71	4·56	2·41	39	1	79	16·76	10	3·35	3·96	3·48
4	39	4	82	58·06	10	−·82	7·24	4·33	45	0	90	16·01	18	2·60	2·08	1·99
5	42	1	85	57·38	15	−1·50	3·24	2·90	41	2	84	16·07	13	2·66	3·88	3·24
6	42	3	87	60·66	17	1·78	2·68	2·96	44	1	89	15·57	18	2·16	2·15	3·06
7	1	1	3	58·50	0	−·38		(33·06)	1	0	2	8·00	0	−5·41		(12·21)
8	44	1	89	59·06	18	·18	2·60	1·13	45	0	90	14·54	18	1·13	3·84	1·80
9	27	5	59	61·82	4	2·94	6·17	4·88	27	13	67	12·00	6	−1·41	5·91	2·25
10	40	5	85	57·56	15	−1·32	2·96	2·25	43	1	87	12·49	17	−·92	2·17	2·01
11	36	8	80	56·66	10	−2·22	2·90	2·66	27	15	69	16·77	6	3·36	4·91	1·95
12	31	10	72	54·49	7	−4·39	3·32	2·77	39	2	80	12·88	10	−·53	3·70	1·33
13	40	5	85	61·32	15	2·44	3·24	2·98	41	4	86	13·87	16	·46	1·55	2·65
14	44	1	89	59·31	18	·43	1·81	2·34	45	0	90	12·23	18	−1·18	2·28	1·05
15	44	1	89	62·41	18	3·53	2·65	3·08	42	1	85	14·51	15	1·10	1·57	2·77
16	43	2	88	60·86	18	1·98	1·92	2·11	40	5	85	13·43	15	·02	2·47	2·96
17	29	10	68	59·92	6	1·04	4·02	3·26	37	6	80	14·23	10	·82	1·93	1·90
18	43	2	88	58·39	18	−·49	1·96	1·99	45	0	90	15·47	18	2·06	5·02	1·00
19	39	5	83	56·26	10	−2·62	3·90	2·43	39	6	84	11·68	13	−1·73	2·76	1·86
20	44	1	89	60·26	18	1·38	1·25	·83	45	0	90	12·28	18	−1·13	1·07	1·36
21	37	7	81	57·50	10	−1·38	2·08	1·59	38	5	81	12·70	10	−·71	2·77	1·34
22	44	1	89	58·94	18	·06	3·56	1·85	45	0	90	12·91	18	−·50	1·43	2·21
23	43	2	88	59·93	18	1·05	2·09	1·35	45	0	90	13·87	18	·46	2·40	1·64
24	43	2	88	55·29	18	−3·59	3·13	2·29	43	2	88	9·72	18	−3·69	2·69	1·49
25	16	8	40	50·58	2	−8·30	11·30	7·71	20	11	51	5·62	3	−7·79	6·58	2·97
26	44	1	89	60·72	18	1·84	1·38	·99	44	1	89	14·40	18	·99	1·30	1·38
27	44	1	89	57·12	18	−1·76	1·07	1·26	45	0	90	14·38	18	·97	2·50	1·96
28	26	8	60	63·55	4	4·67	2·03	2·70	32	9	73	10·42	7	−2·99	1·68	2·77
29	44	1	89	59·96	18	1·08	1·49	1·82	45	0	90	16·69	18	3·28	2·81	2·68
30	43	2	88	59·88	18	1·00	1·77	1·79	44	0	88	10·88	18	−2·53	2·61	2·60
31	33	8	74	60·35	8	1·47	3·21	1·85	27	7	61	12·02	5	−1·39	11·87	4·43
32	34	7	75	62·89	8	4·01	5·25	4·82	43	1	87	13·45	17	·04	2·60	1·80
33	42	3	87	59·28	17	·40	3·39	3·09	41	3	85	17·16	15	3·75	3·99	3·01
34	19	18	56	51·65	4	−7·23	4·64	3·12	30	7	67	9·46	6	−3·95	4·39	3·38
35	37	5	79	60·90	10	2·02	2·68	2·71	40	3	83	14·73	12	1·32	1·47	1·92
36	30	7	67	63·22	6	4·34	2·66	4·36	31	9	71	11·12	7	−2·29	2·94	3·00
37	39	6	84	55·94	15	−2·94	2·57	2·47	43	2	88	15·98	18	2·57	1·88	1·48
38	44	1	89	58·78	18	−·10	1·47	2·26	44	1	89	12·39	18	−1·02	1·72	2·45
39	44	1	89	57·46	18	−1·42	1·95	1·45	44	1	89	12·46	18	−·95	·96	1·13
40	28	3	59	60·29	4	1·41	6·61	3·10	27	1	55	12·83	4	−·58	5·27	4·83
41	37	8	82	56·95	10	−1·93	2·16	1·63	39	2	80	13·46	10	·05	3·43	2·86
42	44	1	89	55·47	18	−3·41	1·62	1·49	44	1	89	16·38	18	2·97	1·60	1·47
43	41	4	86	60·72	16	1·84	2·56	1·76	45	0	90	13·81	18	·40	1·89	1·33
44	44	1	89	58·67	18	−·21	1·55	1·85	45	0	90	13·03	18	−·38	2·98	2·71
45	42	3	87	58·07	17	−·81	1·35	2·51	40	5	85	12·86	15	−·55	6·95	2·91
46	43	2	88	58·92	17	·04	1·40	·85	45	0	90	13·79	18	·38	·78	1·79
47	37	3	77	61·31	9	2·43	4·38	2·54	40	4	84	11·15	13	−2·26	3·52	3·30
48	44	1	89	56·29	18	−2·59	2·62	2·02	45	0	90	12·76	18	−·65	2·88	1·91
49	44	1	89	57·11	18	−1·77	4·84	1·00	45	0	90	11·28	18	−2·13	2·52	1·32
50	43	1	87	61·34	17	2·46	2·41	1·33	44	0	88	11·77	18	−1·64	1·70	1·38
51	30	5	65	60·65	6	1·77	2·88	3·31	31	7	69	8·39	6	−5·02	5·45	2·67
52	10	9	29	54·10	0	−4·78	13·92	3·71	12	8	32	10·58	0	−2·83	5·60	2·99
53	23	9	55	57·40	4	−1·48	3·54	3·64	26	6	58	15·41	4	2·00	7·19	3·75
54	44	1	89	55·14	18	−3·74	3·59	1·89	45	0	90	13·49	18	·08	2·47	1·96
55	37	9	83	59·92	10	1·04	3·39	1·84	39	5	83	18·62	12	5·21	2·37	1·40
56	36	7	79	59·37	10	·49	3·14	1·99	44	0	88	13·88	18	·47	2·70	2·33
57	32	13	77	61·62	11	2·74	1·75	1·40	42	3	87	10·59	17	−2·82	2·16	1·65
58	44	1	89	57·60	18	−1·28	1·60	1·42	45	0	90	13·22	18	−·19	1·42	1·36
59	38	4	80	58·07	10	−·81	5·80	2·32	37	6	80	12·45	10	−·96	8·89	3·57
60	42	3	87	61·31	17	2·43	3·00	1·39	34	8	76	11·76	9	−1·65	3·63	2·60
61	44	1	89	58·17	18	−·71	1·28	·74	45	0	90	12·11	18	−1·30	1·27	·89
62	44	1	89	59·80	18	·92	1·52	1·57	45	0	90	12·66	18	−·75	2·07	1·81
63	29	9	67	59·92	6	1·04	3·26	3·06	31	6	68	15·57	6	2·16	2·37	1·88
64	44	1	89	57·97	18	−·91	2·00	1·52	44	1	89	13·48	18	·07	2·10	2·06
65	44	1	89	59·62	18	·74	2·73	4·59	42	3	87	14·89	17	1·48	3·35	2·47
66	23	4	50	56·57	3	−2·31	2·39	2·01	24	5	53	12·08	3	−1·33	7·55	2·63

of the quality of the image given by the frequency with which it has been chosen for measurement.

The deviations Δ from the weighted mean as they are given in Table 2 are practically only due to defects of the image concerned. Arranged according to the weight p and divided into three groups the following mean values are obtained:

number of images $n_{\Delta\alpha \cos\delta} + n_{\Delta\delta}$	weight	$\Delta^2 = I$	2 M
54	18·0	3·0	3·6
42	13·2	4·2	4·7
32	5·5	13·0	7·1

Here it is again confirmed (comp. *Potsdam Publ.* 63 Vol. **22**, p. 16) that the square of the mean error of one setting is about equal to that arising from defects of the image.

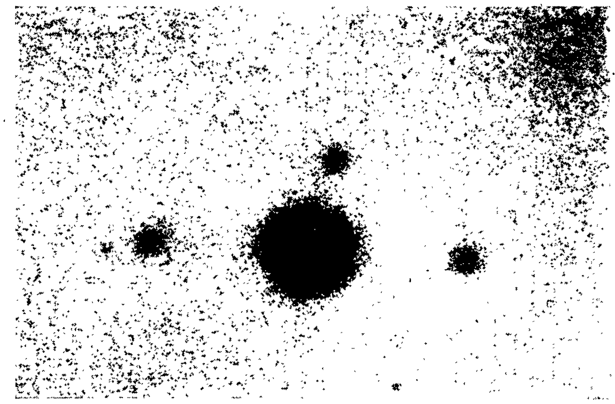


FIGURE 1.

Image of Antares 61 times enlarged, thus corresponding to an equivalent focal length of 665 metre.

TABLE 3.
Image no. 22.

measured by	$\Delta\alpha \cos\delta$				$\Delta\delta$			
	$2f$ −300	$2g$ −300	Σ	Δ	$2f$	$2g$	Σ	Δ
E. HERTZSPRUNG	11	6	17	5	24	36	60	12
G. P. KUIPER	23	12	35	11	19	31	50	12
P. TH. OOSTERHOFF	6	17	23	11	22	26	48	4
W. H. VAN DEN BOS	20	16	36	4	23	24	47	1
D. REUYL	25	16	41	9	23	28	51	5
M. SCHWARZSCHILD	22	25	47	3	31	28	59	3
K. AA. STRAND	12	13	25	1	25	22	47	3
J. MERGENTALER	21	(18)			31	30	61	1
F. DE HAAS	19	18	37	1	28	26	54	2
MISS H. A. KLUYVER	15	23	38	8	25	25	50	0
J. M. ABRAMS	22	24	46	2	28	13	41	15
J. DE KORT	27	18	45	9	22	31	53	9
D. GAYKEMA	15	9	24	6	22	27	49	5
A. VAN HOOF	16	22	38	6	22	29	51	7
J. ZEEMAN	24	19	43	5	30	27	57	3
C. J. KOOREMAN	21	18	39	3	22	28	50	6
A. J. WESSELINK	17	15	32	2	26	30	56	4
L. PLAUT	17	11	28	6	26	25	51	1
A. DE SITTER	18	25	43	7	25	22	47	3
G. VAN HERK	18	21	39	3	32	26	58	6
R. PRAGER	18	20	38	2	26	29	55	3
J. H. OORT	23	23	46	0	25	25	50	0
C. H. HINS	20	22	42	2	28	25	53	3
A. BLAAUW	21	22	43	1	22	25	47	3
J. UITTERDYK	21	25	46	4	26	27	53	1
W. CHR. MARTIN	12	18	30	6	30	25	55	5
G. PELS	11	13	24	2	20	25	45	5
C. SANDERS	9	19	28	10	27	25	52	2
L. BINNENDYK	17	22	39	5	22	26	48	4
H. KLEIBRINK	18	14	32	4	23	37	60	14
H. VAN GENT	20	22	42	2	24	27	51	3
J. G. FERWERDA	22	20	42	2	26	31	57	5
R. ROELOFS	16	19	35	3	24	26	50	2
F. NISOLI	14	21	35	7	26	24	50	2
J. SCHILT	14	19	33	5	16	27	43	11
W. J. LUYTEN	19	7	26	12	25	31	56	6
H. M. JEFFERS	24	19	43	5	27	25	52	2
J. M. KRIEST	18	21	39	3	22	28	50	6
H. W. R. KRAUSS	9	14	23	5	27	33	60	6
G. V. SIMONOV	19	16	35	3	21	33	54	12
M. RUDKJØBING	16	15	31	1	24	29	53	5
A. D. THACKERAY	20	19	39	1	24	25	49	1
P. SÉMIROT	16	10	26	6	23	24	47	1
W. H. DIRKS	23	18	41	5	22	28	50	6
D. BENNINK	18	18	36	0	21	22	43	1

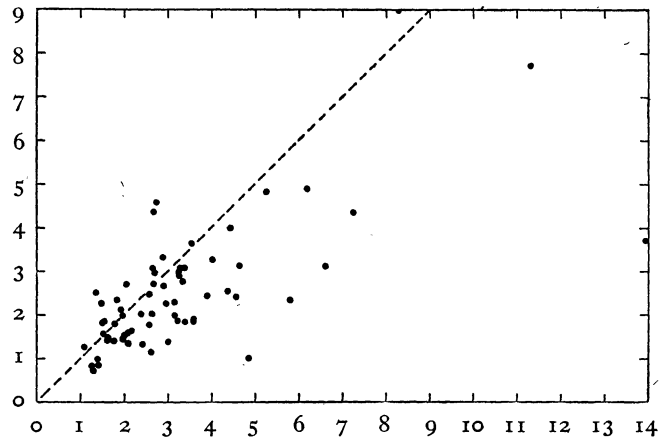
In Table 3 the complete measures on the image no. 22 as made by different persons are listed. One setting was made on each of the two diffraction images of the brighter component. The difference between the sum of these two settings and twice the setting on the central image of the companion is for each person given in Table 3 separately for $\Delta\alpha \cos\delta$ and $\Delta\delta$ and for measures with the film turned toward the microscope (f) and through the glass (g). The sums of the powers 0, 1 and 2 of $2f - 300 + 2g - 300$ for $\Delta\alpha \cos\delta$ are respectively 44, 1570 and 58472. The square of the mean deviation in $2f + 2g$ for one person therefore is $(44 \times 58472 - 1570^2)/44 \times 43 = 57$ or in $(f+g)/2$ $57/16 = 3{\cdot}56\,\mu^2$. This is the figure entered under the heading M + P in the 8th column of Table 2. The mean square of the difference between $2f$ and $2g$ is $1300/44 = 29{\cdot}5$. The figure $29{\cdot}5/16 = 1{\cdot}85\,\mu^2$ is found under the heading M in the 9th column of Table 2. M is thus the square of the mean error of setting involved in the mean value of $(f+g)/2$ and P is the square of the mean personal error.

In Table 4 the measures executed by RUDKJØBING, the only person who made complete measures of all the images, are given. The sums of the powers 0, 1 and 2 of $2f$ and $2g$ for $\Delta\delta$ are respectively for f: 66, 1764 and 51162 and for g: 66, 1660 and 44876. The sum of the squares of the deviations from the mean therefore is for $2f$: $(66 \times 51162 - 1764^2)/66 = 4015$ and for $2g$: $(66 \times 44676 - 1660^2)/66 = 2924$. The square of the mean deviation therefore is in the mean for $2f$ and $2g$: $(4015 + 2924)/(66 + 66 - 2) = 53{\cdot}4$ or for f and g $53{\cdot}4/4 = 13{\cdot}4\,\mu^2$. This is the figure entered in the last column of Table 1 under the heading 2 M + I, where I is the square of the mean error due to imperfections of the image.

TABLE 4.
Measures by RUDKJØBING.

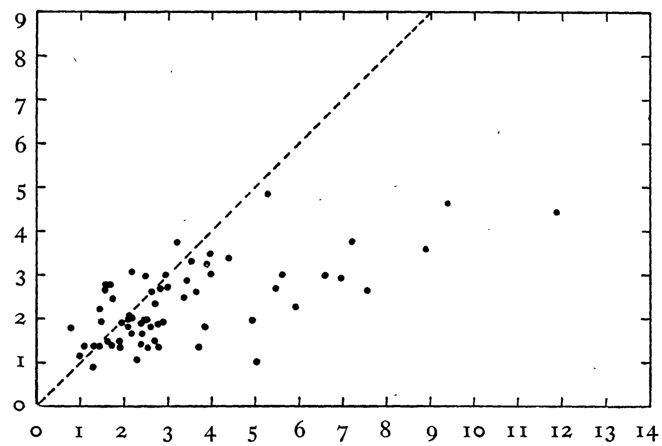
image no.	$\Delta\alpha \cos\delta$ 2f — 300	2g — 300	Σ	Δ	$\Delta\delta$ 2f	2g	Σ	Δ
1	19	24	43	5	17	21	38	4
2	10	15	25	5	15	15	30	0
3	18	17	35	1	47	29	76	18
4	8	1	9	7	25	30	55	5
5	18	10	28	8	28	32	60	4
6	22	26	48	4	33	24	57	9
7	1	— 22	— 21	23	9	23	32	14
8	12	13	25	1	18	22	40	4
9	24	22	46	2	27	25	52	2
10	24	16	40	8	22	30	52	8
11	14	14	28	0	29	27	56	2
12	6	4	10	2	32	27	59	5
13	40	24	64	16	30	29	59	1
14	18	13	31	5	21	24	45	3
15	19	32	51	13	32	17	49	15
16	23	20	43	3	20	21	41	1
17	12	15	27	3	35	32	67	3
18	13	22	35	9	36	27	63	9
19	13	18	31	5	26	24	50	2
20	23	25	48	2	28	20	48	8
21	21	18	39	3	29	31	60	2
22	16	15	31	1	24	29	53	5
23	24	23	47	1	35	29	64	6
24	14	9	23	5	16	20	36	4
25	16	2	18	14	19	6	25	13
26	14	23	37	9	28	25	53	3
27	12	14	26	2	19	33	52	14
28	28	30	58	2	24	12	36	12
29	22	21	43	1	39	29	68	10
30	13	22	35	9	21	28	49	7
31	23	23	46	0	15	28	43	13
32	27	29	56	2	20	25	45	5
33	17	21	38	4	40	30	70	10
34	— 8	— 1	— 9	7	23	11	34	12
35	28	28	56	0	38	29	67	9
36	22	32	54	10	37	23	60	14
37	15	14	29	1	31	30	61	1
38	15	14	29	1	23	24	47	1
39	11	19	30	8	29	22	51	7
40	28	27	55	1	24	12	36	12
41	6	14	20	8	27	25	52	2
42	12	10	22	8	31	35	66	4
43	22	18	40	4	27	28	55	1
44	12	27	39	15	39	27	66	12
45	15	13	28	2	8	24	32	16
46	11	21	32	10	19	34	53	15
47	19	21	40	2	24	11	35	13
48	11	14	25	3	22	33	55	11
49	9	12	21	3	28	23	51	5
50	22	24	46	2	20	15	35	5
51	21	22	43	1	15	13	28	2
52	— 10	— 9	— 19	1	30	23	53	7
53	30	6	36	24	23	35	58	12
54	4	7	11	3	22	31	53	9
55	13	17	30	4	40	35	75	5
56	7	19	26	12	30	25	55	5
57	24	32	56	8	25	26	51	1
58	21	15	36	6	29	23	52	6
59	12	10	22	2	37	37	74	0
60	12	17	29	5	26	25	51	1
61	10	16	26	6	24	19	43	5
62	12	20	32	8	19	24	43	5
63	18	17	35	1	36	38	74	2
64	13	17	30	4	36	23	59	13
65	20	15	35	5	35	23	58	12
66	10	15	25	5	28	30	58	2

FIGURE 2.



$\Delta\alpha \cos\delta$, abscissa: M+P, ordinate: M.

FIGURE 3.



$\Delta\delta$, abscissa: M+P, ordinate: M.

In Figures 2 and 3 the relation between M + P as abscissa and M as ordinate is represented by a point for each image as measured by different persons. The existence of personal errors will therefore manifest itself by a preference of the points to lie below the 45° line.

Though no general conclusion can be drawn from a single plate measured by a number of persons small from a statistical point of view the evidence available supports the idea that personal errors exist also in photographic measures of double stars and that they are of two kinds, viz. 1° personal errors mainly in distance (in casu practically in $\Delta\alpha \cos\delta$) due to the presence of an image close to the one pointed at and 2° personal differences in the interpretation of faint