ASTRONOMISCHE NACHRICHTEN.

N^o 3269.

Band 137.

5.

Comparison of Photometric Magnitudes of the Stars.

By *Edward C. Pickering.*

In the ninth volume of the Publications of the Observatory at Potsdam the photometric magnitudes obtained at that institution are compared with the results of three other photometric catalogues. These are the Uranometria Oxoniensis, the Harvard Photometry (Harvard Annals, Vol. XIV) and the results contained in Volume XXIV of the Harvard Annals. From this it appears that the number of stars in each of these catalogues observed also at Potsdam is 691, 791, and 801 respectively. The number of cases in which the difference exceeds half a magnitude, after applying a correction for the systematic difference due to the color of the stars, is similarly 21, 6, and 13 in the three cases. As this correction is almost exactly the same for the Oxford and Harvard Catalogues, it has been found convenient in the following table to apply the correction for color to the Potsdam magnitudes. As no comparisons are made in the Potsdam volume, of the magnitudes of the stars observed both at the Oxford and Harvard Observatories, it seems worth while to give them below, especially as later observations of many of these stars have also been obtained

at this observatory in the reobservation, now nearly completed, of all the stars contained in the Harvard Photometry.

In the following table the 40 stars mentioned above, and enumerated in the Potsdam volume page 500, are given on successive lines. The number from the Potsdam catalogue in the first column is followed by the magnitudes in the five catalogues mentioned above. They are arranged in chronological order as the mean year of observation of the Harvard Annals Volume XIV is 1881, of the Uranometria Oxoniensis 1884, Harvard Annals Volume XXIV, 1885, Potsdam Observations 1889, and the revision of the Harvard Photometry 1893. The means and residuals of these magnitudes are given in the subsequent columns when a star appears in more than two catalogues. Stars 1813 and 3343 appear twice in the table and the residuals for the second entry are therefore omitted. Stars 122, 185, 653, 3327, and 3361 occur in both Tables I and IV of Volume XXIV and the mean of the magnitudes is accordingly entered in the table.

No.	1881 Harvard XIV	1884 Oxford	1885 Harvard XXIV	1889 Pots- dam	1893 Rev. H. Ph.	Mean	Residuals				
Oxford, Potsdam.											
10	3.04	2.47	2.77	3.02	2.85	2.83	+.21	-.36	-.06	+.19	+.02
318	5.78	5.72	..	6.22	6.14	5.96	-.18	-.24	..	+.26	+.18
332	2.68	2.44	2.93	2.93	2.80	2.76	-.08	-.32	+.17	+.17	+.04
638	..	6.06	..	7.22	..	..	..	..	..	..	..
849	5.66	5.61	..	6.12	5.89	5.82	-.16	-.21	..	+.30	+.07
899	4.40	4.89	4.38	4.36	4.13	4.43	-.03	+.46	-.05	-.07	-.30
984	4.62	5.19	4.71	4.63	4.50	4.73	-.11	+.46	-.02	-.10	-.23
990	5.62	5.45	6.02	5.98	5.91	5.80	-.18	-.35	+.22	+.18	+.11
1754	6.30	6.19	6.95	6.71	6.58	6.55	-.25	-.36	+.40	+.16	+.03
1813	5.59	5.65	6.04	6.18	6.27	5.95	-.36	-.30	+.09	+.23	+.32
1917	6.61	6.30	6.74	6.82	6.81	6.66	-.05	-.36	+.08	+.16	+.15
2171	..	7.13	..	6.56	6.64	6.78	..	+.35	..	-.22	-.14
2610	..	3.91	..	4.73	4.56	4.40	..	-.49	..	+.33	+.16
2611	..	4.23	..	5.16	..	..	..	..	..	..	..
2622	5.24	5.03	5.57	5.56	5.44	5.37	-.13	-.34	+.20	+.19	+.07
2756	6.64	6.31	6.81	6.88	6.64	6.66	-.02	-.35	+.15	+.22	-.02
2776	5.69	5.45	5.91	5.93	5.74	5.74	-.05	-.29	+.17	+.19	.00
3026	4.13	3.59	3.80	4.17	3.99	3.94	+.19	-.35	-.14	+.23	+.05
3327	5.18	4.99	5.50	5.50	5.25	5.28	-.10	-.29	+.22	+.22	-.03
3343	5.27	5.05	5.67	5.78	5.44	5.44	-.17	-.39	+.23	+.34	.00
3414	2.61	2.33	2.49	2.94	2.66	2.61	.00	-.28	-.12	+.33	+.05

No.	1881 Harvard XIV	1884 Oxford	1885 Harvard XXIV	1889 Pots- dam	1893 Rev. H. Ph.	Mean	Residuals				
Harvard XIV, Potsdam.											
1737	6.75	6.47	6.30	6.25	6.41	6.44	+ .31	+ .03	— .14	+ .19	— .03
1813	5.59	5.65	6.04	6.18	6.27	5.95	..	..	..	..	..
2044	5.71	5.79	..	6.25	5.90	5.91	— .20	— .12	..	+ .34	— .01
2326	6.45	..	..	5.58	5.59	5.87	+ .58	..	..	— .29	— .28
2918	6.01	6.00	..	5.50	5.91	5.86	+ .15	+ .14	..	— .36	+ .05
3343	5.27	5.05	5.67	5.78	5.44	5.44	..	..	..	..	..
Harvard XXIV, Potsdam.											
122	5.68	5.60	5.79	5.50	5.59	5.63	+ .05	— .03	+ .16	— .13	— .04
185	..	..	6.21	6.50	6.30	6.34	..	..	— .13	+ .16	— .04
245	5.55	5.50	6.15	5.60	5.52	5.66	— .11	— .16	+ .49	— .06	— .14
653	6.49	..	6.62	6.22	6.81	6.54	— .05	..	+ .08	— .32	+ .27
1218	..	..	7.71	9.05	..	..	..	..	..	..	..
1698	..	..	6.75	7.02	..	..	..	..	..	..	..
1699	..	..	7.70	7.56	..	..	..	..	..	..	..
1752	..	..	6.93	6.36	..	..	..	..	..	..	..
2395	..	..	6.48	5.98	5.83	6.10	..	..	+ .38	— .12	— .27
2535	..	..	8.20	7.64	..	..	..	..	..	..	..
3094	..	..	6.91	7.73	..	..	..	..	..	..	..
3166	..	..	8.07	7.44	..	..	..	..	..	..	..
3361	3.59	3.29	3.78	3.48	3.42	3.51	+ .08	— .22	+ .27	— .03	— .09
Average Deviations							± .15	± .29	± .18	± .21	± .11

From the average deviations given in the last line the order of excellence of the first three catalogues appears to be the same as that found at Potsdam, Harvard XIV first, Harvard XXIV second, and Oxford third. Moreover, the Potsdam observations are more accordant than the Oxford, and the recent Harvard work more accordant than any. The observations in Volume XIV were made with an instrument smaller and inferior to that used in the later Harvard work, but as the minimum number of nights observations was three instead of two, the average deviations for Volumes XIV and XXIV do not differ greatly. It should be noticed that the above stars are in general the most discordant in the catalogues as they include all the stars in which the results differ more than half a magnitude. The average deviations of the other stars would be much less. To treat the three catalogues, Oxford, Potsdam, and Harvard XIV symmetrically, stars differing in Oxford and Harvard XIV by half a magnitude should also be included. On examination it appeared that there were only two such stars, 984 and 3026 in the part of the sky here under discussion, and these are already included in the above list among the stars differing at Potsdam and Oxford. The Harvard results agree more closely with both the Potsdam and the Oxford measures than the latter do with one another, the number of differences in the three cases exceeding half a magnitude being 6, 2, and 21 respectively. In the average deviations given below it might be thought that the results were affected by errors persisting in all the measures made with the meridian photometer. This would not be likely to occur as two different instruments were

used and an interval of several years occurred between the second and third series during which the instrument was dismantled and sent to South America and a long series of measures made with it there. There is no evidence of such a persistence in the corresponding residuals. A re-computation has however been made taking the mean of all the meridian photometer observations of each star and giving equal weights to this mean, to the Potsdam, and to the Oxford results. The average deviations then become, for Potsdam 0.21, for Oxford 0.27 and for Harvard 0.11. The differences in the three Harvard catalogues separately become for Volume XIV 0.17, Volume XXIV 0.21 and for the revision of the Harvard Photometry 0.12. *The differences in the different catalogues cannot be mainly due to progressive changes in light of the stars or we should expect the first and last catalogues to give the largest average deviations, also that the extreme values would occur most frequently in these catalogues. A count of these extreme values shows that the number for each catalogue is, for Harvard XIV 6, for Oxford 20, for Harvard XXIV 10, for Potsdam 19, and for the revision of the Harvard Photometry 5. The order is again the same as for the average deviations.

The positions of 1698 and 1699 were interchanged in printing Volume XXIV. Their magnitudes as given in Volume XXIV have therefore been transposed in the above table since the stars were entered correctly in the observing list, and correctly observed. In fact, on three of the four nights on which they were measured the observer noted the position of the adjacent star. A large part of the errors

of Volume XXIV such as those relating to BD. +59°76 (Astr. Nachr. Vol. 136, p. 85) are of this class, the stars being correctly observed but the places incorrectly printed. Slight errors in the Durchmusterung, especially in declination were often noticed by the observer but even an error of a minute of time as in the case of BD. +45°921, probably seldom led to the observation of another star, especially when like BD. +69°455 it was near the pole. In this latter instance the error in the Durchmusterung of a minute of time only displaced the star 5' or about one ninth of the diameter of the field. Moreover, on both nights of observation the observer recognized the error by noting that the star had the same right ascension as BD. +70°497. Apparently some other star was observed by mistake for BD. +5°1934.

An attempt has been made throughout the Harvard work to eliminate systematic errors as much as possible, since if this is done the accidental errors can be reduced indefinitely by increasing the number of observations of each star. The accidental errors in either catalogue are of little importance since they affect the final values by only a few hundredths of a magnitude, while the systematic differences amount in some cases to several tenths. At Harvard, when an observation was discordant, the star was reobserved on so many nights that the final value was generally only changed one or two tenths of a magnitude whether the observation was retained or rejected.

The Potsdam astronomers are in error in one respect, in supposing that the Harvard observations were made with undue haste. In quoting from Volume XXIII p. 7, the statement of the speed attained, they have failed to quote the sentence following it. »Care was always taken that

the observer should not be hurried in his measures, and the work was accordingly so divided that he generally had to wait for the recorder.« A star a minute is not an unusual speed for observations of stars in zones with meridian circles where much more accurate measures are required and is never regarded as an evidence of inaccuracy. Under favorable circumstances stars can be observed at this rate with the meridian photometer and the results will have an average deviation of almost exactly a tenth of a magnitude. Of course, several minutes are often spent upon a single star when adjacent stars render its identification uncertain. The great number of measurements obtained may be assigned to two causes. First, as in the case of other meridian instruments, very little time is lost in setting upon the star and identifying it with certainty, so that almost the entire time of the observer is spent in the actual photometric comparisons. Secondly, by long practice, observers and recorders are enabled to perform the mechanical operations with great rapidity.

The average number of stars, not including standards, observed each evening at Potsdam was about twenty, while at this observatory, when the work is not interrupted by clouds it now exceeds one hundred. To fairly compare the two methods the error of the mean of five of our observations of the same star should therefore be compared with that of a single observation at Potsdam. At Oxford ten stars were generally observed each night, four sets of measures being made of each star. The above discussion, with that given elsewhere, shows that the work done with the meridian photometer compares favorably with that obtained by other methods, both as regards speed and accuracy.

Harvard College Observatory, 1894 Oct. 24.

Observations of the Transit of Mercury, November 10, 1894,

at Harvard College Observatory.

(Communicated by *Edward C. Pickering*, Director.)

No observations could be obtained at ingress, owing to clouds.

At egress, the sky around the Sun was clear, but the Sun was very near the horizon, and its limb was extremely ill-defined, the extent of the undulations exceeding the diameter of the disk of Mercury. Five observers obtained determinations of the time of the third contact, and two of them also observed the fourth. The apertures of all the telescopes used were reduced to four inches, except in the case of the East Equatorial, the aperture of which was reduced to six inches.

Each observer was assisted by a recorder, who noted

the time of the signals given him by the observer. The time-pieces employed in these observations were compared shortly before and after the observed phenomena with the standard mean time clock of the Observatory, Bond No. 394, which was regulated accurately to »Eastern Time«, five hours slow of Greenwich Mean Time.

In the following tabular arrangement of the observations, the successive columns name the observer, the telescope employed, its focal length, its magnifying power, the Greenwich Mean Time of the observed contacts, and the uncertainty of each observation according to the judgment of the observer.

Observer	Instrument	Focal length	Power	Times of Contacts	
				Third	Fourth
<i>W. H. Attwill</i>	Portable five-inch refractor	74 inches	74	9 ^h 10 ^m 52.8 ± 5 ^s	—
<i>J. R. Edmands</i>	Refractor by A. Caswell	55 »	140	9 11 20.1 ± 10	—
<i>E. S. King</i>	Finder of East Equatorial	59 »	118	9 10 58.8 ± 5	9 ^h 12 ^m 12.5 ± 10 ^s
<i>E. C. Pickering</i>	West Equatorial	98 »	195	9 10 58.7 ± 10	—
<i>O. C. Wendell</i>	East Equatorial	270 »	135	9 11 2.8 ± 3	9 12 12.1 ± 5