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THE MAGNITUDE EQUATION IN THE RIGHT ASCENSIONS OF THE
EROS STARS

The final places of the Reference stars for Eros have been published in Circular No. 11 of the *Conference Astrophotographique Internationale*. They are based upon the observations made at thirteen observatories, the results of which were published in Circulars No. 8 and No. 9. The original results were first corrected for systematic differences, derived from a discussion of the entire material, made at this observatory, and the weighted combination of the separate sets was then adopted, for the final places.

No investigation of the effect of magnitude upon the observed Right Ascensions, has been made, for the greater part of these results. The existence of such an effect has been very generally admitted. But, up to the present time, no convention has been established for the application of corrections to observed Right Ascensions, even when investigation of the effect has been made.

For the purpose of photographic measures, for which the meridian circle observations are to furnish the reference points, any systematic difference of this character will be of importance: and it may be expected to appear, in the comparison of the photographic measures.

The problem seems, however, to have been further complicated, by the results of comparisons made between separate sets of photographic measures, in which systematic differences, also depending upon the magnitude of the star, appear to be plainly evident. Leaving that phase of the problem for solution by those who will deal with the photographic measures,

the meridian circle results can be subjected to comparative tests, which may indicate the character and extent of the magnitude equation in the final places. In the weighted combination, the residuals of each set, with respect to the mean, when grouped according to magnitude, represent the collected material in the most condensed form.

The two Tables, which follow, give the detailed results of such a comparison, the two lists of Eros stars having been treated separately. The stars have been grouped in the following classes: brighter than 7; mag. 7 to 8; 8 to $8\frac{1}{2}$; $8\frac{1}{2}$ to 9; and for the first list only, a group 9.0 and fainter.

The Tables give the number of stars in each group, for each observatory, and the mean of the corresponding residuals. In the last column is given the Magnitude Equation, or effect due to a difference of one magnitude, assuming a uniform rate throughout the scale of these lists. This is a close enough approximation for the present purpose, though the investigations made at Koenigsberg, with the use of the clock-driven micrometer, indicate that the effect may vary in different parts of the magnitude scale, at least for some observers.

The plus sign, in the Magnitude Equation of these Tables, indicates that the faint stars are observed too late, with respect to the bright stars. Each group of residuals has been given its appropriate weight, in the derivation of the Magnitude Equation, for each authority. The mean magnitudes of these lists are 8.2 and 7.9 for the first and second, respectively.

TABLE I.—FIRST LIST OF EROS STARS.

Catalogue.	Mag. 6.1 No. m.	Mag. 7.5 No. m.	Mag. 8.2 No. m.	Mag. 8.7 No. m.	Mag. 9.2 No. m.	Mag. Eq.
Abbadia	10 +.033	44 +.004	48 +.001	79 -.009	32 -.011	-.0013
Greenwich	19 -.001	55 -.004	44 -.004	73 -.010	14 -.010	-.003
Koenigsberg	19 -.031	66 -.013	66 -.001	107 +.002	48 +.031	+.015
Lick	19 -.014	66 -.005	66 -.002	108 +.004	60 +.015	+.009
Lisbon	19 +.016	66 +.008	66 +.001	108 -.003	60 .000	-.006
Marseilles	16 -.003	54 -.010	13 +.013	—	(2)	+.008
Nice	16 -.011	43 +.016	56 +.008	73 .000	35 -.034	-.009
Paris	18 +.015	58 -.006	60 +.003	94 -.004	51 -.042	-.013
Rome	—	—	—	—	56 +.022	—
S. Fernando	10 -.005	23 +.033	27 +.004	37 -.025	11 -.023	-.017
Strassburg	19 -.016	62 -.004	65 -.005	104 +.008	60 +.003	+.007
Toulouse	12 -.012	41 +.015	38 -.022	62 -.010	33 -.018	-.007
Washington	19 +.012	66 -.003	66 +.001	108 +.007	60 +.004	.000

TABLE II.—SECOND LIST OF EROS STARS.

Catalogue.	Mag. 6.1 No. m.	Mag. 7.5 No. m.	Mag. 8.2 No. m.	Mag. 8.7 No. m.	Mag. Eq.	Red.
Abbadia	45 +.009	66 +.001	73 -.004	126 -.002	-.0004	+.008
Greenwich	21 .000	24 -.003	22 +.010	24 -.017	-.006	+.006
Koenigsberg	47 -.002	72 -.001	72 +.003	128 +.005	+.003	+.015
Lick	49 +.006	78 +.005	80 -.002	139 -.003	-.004	+.008
Lisbon	49 +.001	78 -.002	80 -.001	139 .000	.000	+.012
Marseilles	24 -.005	39 +.009	7 .000	—	+.002	+.014
Nice	35 -.003	57 +.001	55 +.003	104 +.004	+.003	+.015
Paris	46 +.012	77 -.002	72 -.001	136 -.006	-.006	+.006
Rome	—	—	—	3 +.010	—	—
S. Fernando	22 +.035	24 +.007	22 -.013	39 -.012	-.018	-.006
Strassburg	40 -.012	64 -.001	64 +.003	113 +.005	+.007	+.019
Toulouse	47 -.012	71 +.002	74 +.004	128 +.003	+.004	+.016
Washington	49 +.009	78 -.009	80 +.001	139 -.003	-.003	+.009

In these Tables the uniform character of the group differences, in some of the strongest sets of observations, is quite evident. Thus Abbadia, Koenigsberg, Lick, Lisbon, and Strassburg, give clear indication of the magnitude effect, in both lists. There is great variety in the character of the separate equations. And the two lists do not show any decided similarity, for the two sets, made at the same observatory, as a rule. There was considerable variation in the observing practice, however. Thus the two lists were observed with separate instruments, and by different observers, at Washington. At Paris three different instruments were in service. At Greenwich, and at some of the other observatories, the transit observers may have changed. At Marseilles, the brighter classes of stars were mainly observed; and, at Rome, only the faintest.

The tabulated results indicate clearly the difference between any two sets of Right Ascensions, due to magnitude, when the groups are nearly or quite complete. And a reliable determination of the magnitude effect, at any of the observatories, would give an indication of that included in the final places.

The Lick Observatory results may be admitted for a provisional test. The effect of magnitude, upon transits, has been measured here, by screen observa-

tions, at three separate epochs, for the same observer and instrument. The last published value, which includes all the determinations to date, preceding and following the Eros work, is given in Lick Observatory Bulletin No. 43. This value, 0.007s. per mag., was determined by transits of clock stars, and if it be assumed to vary with the Declination, at least for a limited range, the correction would be 0.010s. per mag. for the first list; and 0.008s. for the second.

Since this correction agrees in sign, and so closely in amount, with that derived in the above Table, for the first list, the inference would be that the final places of that list require no correction for the effect of magnitude. This will be best illustrated by placing the observed and computed values together, as below:

Lick:	6.1	7.5	8.2	8.7	9.2	Mag. Eq
Observed.	-.014	-.005	-.002	+.004	+.015	+.009
Computed.	-.019	-.005	+.002	+.007	+.012	+.010

Confirmation of this evidence is found in the Koenigsberg series. In the Koenigsberg volume for 1903, there are published the corrections derived from comparisons between the results of direct transits, and those recorded by the clock-driven micrometer. It has been assumed that the last should be free from any

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effect due to magnitude. The resulting corrections to direct transits vary in amount, for different parts of the magnitude scale, and such variation is represented below, in the comparison of observed and computed values:

Koenigsberg:	6.1	7.5	8.2	8.7	9.2	Mag. Eq.
Observed.	—0.031	—0.013	—0.001	+0.002	+0.031	+0.015
Computed.	—0.037	—0.015	+0.001	+0.015	+0.030	+0.022 Var.

The Koenigsberg Right Ascensions, given in Circulares No. 8 and No. 9, and which were used for the present comparisons, were later adjusted; in part to conform to a corrected Fundamental system. On account of the differences thus introduced, previous to the comparison with the clock-driven micrometer, the series can only be considered as confirming in a general way the evidence given by the Lick series.

The comparisons of the second list of Reference Stars give results which are quite different in character from those of the first list. The method and details of the comparison are identical, yet the individual sets, made at the same observatory, are not alike; and finally, the Normal system of Right Ascensions of the second list would appear to require a correction depending upon magnitude. From the evidence of the Lick series, the correction appears as a magnitude equation of 0.012s.

In the following arrangement of the comparison, the observed value is compared with the computed value, based upon the screen determination. The difference of the two may then be directly compared with the assumed value of the correction to the final Right Ascensions, 0.012s.

Lick:	6.1	7.5	8.2	8.7	Mag. Eq.
Observed.	+0.006	+0.005	+0.002	—0.003	—0.004
Computed.	—0.017	—0.006	.000	+0.004	+0.008
Diff.	—0.023	—0.011	+0.002	+0.007	
Assumed.	—0.025	—0.008	.000	+0.006	+0.012

The Koenigsberg results for the second list can be treated in a similar manner. The assumed correction to the Normal system of Right Ascensions is treated, however, as of uniform variation, here.

Koenigsberg:	6.1	7.5	8.2	8.7	Mag. Eq.
Observed.	—0.002	—0.001	+0.003	+0.005	+0.003
Computed.	—0.036	—0.013	+0.002	+0.016	+0.020 Var.
Diff.	—0.034	—0.012	—0.001	+0.011	
Assumed.	—0.023	—0.006	+0.002	+0.008	+0.012

The series confirms, in general, the comparison with Lick; indicating, as in the first list, a larger correction to the Normal system. The individual magni-

tude equations, derived for the second list, have been adjusted to correspond with the correction derived above for the Normal system, the results being given in the last column of the Table of detailed results.

In the following table of corrections for magnitude for the second list, the reduction is given for the mean magnitude, and also for the brighter end of the scale.

Corr.	Mag.	Corr.
0.000	5.0	+0.035
—0.012	6.0	+0.023
—0.024	7.0	+0.011
—0.036	8.0	—0.001
—0.048	9.0	—0.013

In this connection the places of the two lists have been compared with the observations made at Koenigsberg, with the clock-driven micrometer, mainly in 1902, and which were not included in the material discussed in the formation of the Normal System. The results of this comparison follow below.

First List:	6.1	7.5	8.2	8.7	9.2	Sys. Diff. Mag. Eq.
T—K	+0.014	+0.032	+0.047	+0.059	+0.075	+0.050 +0.022

Second List:	T—K	+0.007	+0.023	+0.036	+0.047		+0.034	+0.016
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The comparisons for the first list give results that are difficult to account for, with the evidence already made use of. The Normal system would appear to require about the same correction as the original Koenigsberg Right Ascensions.

The results for the second list are, however, more nearly in accord with this comparison, indicating a magnitude equation in the Normal system of .016s., as compared with .012s., given by the Lick series.

In a late number of Nature (Dec. 15, 1904), attention was called to a suspected systematic difference between the Right Ascensions derived by Loewy, and by Tucker, due presumably to "magnitude equation." When the two systems of Right Ascensions are compared thoroughly, the difference of magnitude equation is found to be very small for the first list, and to be quite inappreciable for the second. The results of a very slight examination are apt to be misleading. The comparisons follow.

First List:	6.1	7.5	8.2	8.7	9.2	Sys. Diff. Mag. Eq.
T—L	+0.003	0.000	—0.002	—0.003	—0.009	—0.003 —0.004

Second List:	T—L	—0.001	—0.002	—0.001	—0.003		—0.002	.000
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Mr. Elliott Smith, Carnegie Institution Assistant, has aided me in the details of these comparisons.

R. H. TUCKER.

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