

ROYAL OBSERVATORY, GREENWICH.

APPENDIX II.

REDUCTION

OF THE

GREENWICH PLANETARY OBSERVATIONS,

1831 TO 1835.

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[A]

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GREENWICH PLANETARY OBSERVATIONS,

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IN the *Reduction of the Observations of Planets made at the Royal Observatory, Greenwich, from 1750 to 1830*, the reductions were carried to such a stage as to exhibit comparisons of the observed places with places computed from the best Solar and Planetary tables then in existence ; in the form of equations between the Errors of the Tabular Heliocentric Radius and Errors of the Tabular Heliocentric Longitude, and of direct exhibition of the Errors of the Tabular Heliocentric Latitude. In the volumes of *Greenwich Observations* commencing with 1836, the reductions of observations of the planets have been uniformly brought to the same stage. The observations for the intervening period, 1831 to 1835, were not reduced in the same way.

At the suggestion of Hugh Breen, Esq. (formerly Assistant of the Royal Observatory), and at my recommendation, the reduction of the Planetary Observations 1831 to 1835 was made, at the expense of the Admiralty, by Mr. Breen. The final results were exhibited in a form generally identical with that of the *Reduction, &c.*, 1750 to 1830.

The following statement and tables describe the form of the computations and exhibit their results, with all the details which appear necessary ; referring for many numbers to printed volumes of *Greenwich Observations* or other works.

1. The right ascensions of the “parts observed” of all the planets are taken from the “Fifth Parts” of the *Greenwich Observations* for their respective years, with the following corrections :—

1831	—0 ^h 03
1832	—0 ^h 03
1833	—0 ^h 03
1834	—0 ^h 03
1835	0 ^h 00

The investigation of these corrections is given in the Introduction to the *Reduction of the Observations of the Moon, 1831 to 1851*.

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2. When the transit of the planet's center has been observed, no farther correction is applied. When the transit of a limb has been observed, the time of passage of semidiameter is computed from the following elements :—

For Mercury, using Le Verrier's value $3''.34$ at Sun's mean distance from the Earth.

For Venus, using $8''.25$ at Sun's mean distance, and further correcting the result by application of the quantity $+0''.05 + 0''.03 \times \text{tabular semidiameter in R.A.}$ (investigated in the Introduction to the *Greenwich Observations* 1838).

For Mars, using Le Verrier's value $5''.55$ at Sun's mean distance.

For Saturn, using the value adopted in the *Nautical Almanac*, $81''.106$ at Sun's mean distance.

3. The North Polar Distances are calculated from the observed circle readings, printed in the four quarterly parts of the *Greenwich Observations*, by application of the Zenith Points given in the "Fifth Parts." The means of the results of Troughton's Circle and Jones' Circle are adopted. When the planet is observed at the 5th wire, the corrections for change of N.P.D. and for curvature of path are applied.

4. When the center of the planet is observed, or when opposite limbs are observed with Troughton's and Jones' Circles, no farther correction is required for semidiameter.

When only one limb has been observed, the semidiameter is computed from the measure made with the circle-micrometer, or, in default of it, with the same elements as for right ascension.

5. The refractions are computed by Bessel's tables, in the form given in the Appendixes to the *Greenwich Observations* 1836 and 1853. The parallaxes are computed by the formula $[0.9325] \times \text{reciprocal of planet's distance from earth} \times \text{sine (zenith distance} - 11'.12'')$. The log. distance is taken from the *Berliner Jahrbuch* for 1831, 1832, 1833, and from the *Nautical Almanac* for 1834, 1835. The colatitude employed is $38.^\circ 31'.21''.93$.

6. The succeeding calculations are conducted on two different principles for two groups of planets. The first group includes Mercury, Venus, Mars; the second group includes the Small Planets, Jupiter, Saturn, Uranus.

7. For Mercury, Venus, and Mars, the Right Ascensions and North Polar Distances are converted, by calculation, into Longitudes and Ecliptic Polar Distances. The obliquity of Ecliptic is calculated from Le Verrier's Solar Tables. The result of every separate observation of each of these planets is thus exhibited in Geocentric Longitude and Geocentric Ecliptic N.P.D.

8. To compare these with Tabular Geocentric Longitude and Tabular Geocentric Ecliptic N.P.D., the Mean Solar Time of each observation is taken from the "Fifth Part." With this time unaltered, the three co-ordinates of the earth referred to the Sun are computed from Le Verrier's Solar Tables (*Annales de l'Observatoire*, tome iv); those of Mercury from Le Verrier's Tables (*Annales*, tome v); those of Venus from Le Verrier's Tables (*Annales*, tome vi); and those of Mars from Le Verrier's Tables (in the same volume).

9. With these co-ordinates, the geometrical co-ordinates of each Planet with respect to the Earth's center are computed for each observation. Then the "time for aberration" is computed by the formula $499^{\text{s}}.15 \times \text{Planet's distance from Earth}$. The change of heliocentric co-ordinates of earth and of each planet, corresponding to the "time for aberration," is applied negatively to the heliocentric co-ordinates previously computed; and with these corrected heliocentric co-ordinates the corrected or visible geocentric co-ordinates are computed by complete repetition of the calculation.

10. Each Geocentric Longitude and Ecliptic N.P.D. thus computed is compared with that found in Article 7, and the apparent tabular error in Geocentric Longitude and Ecliptic N.P.D. is found for each. The observations are grouped as appears convenient and permissible, and the mean error of the tables in Geocentric Longitude and Ecliptic N.P.D. is taken.

11. These mean errors are considered as having originated from tabular errors of Heliocentric Radius Vector, Longitude, and Ecliptic N.P.D. And (exactly as in the *Reduction of the Observations of Planets 1750 to 1830*, and as in the later volumes of *Greenwich Observations*,) the error in Heliocentric E.P.D. is found, and the equation is formed which exhibits the relation between the errors of Heliocentric Radius Vector and Heliocentric Longitude; and this completes the operation for Mercury, Venus, and Mars.

12. For the other group, including the Small Planets, Jupiter, Saturn, and Uranus, the treatment has been generally similar to that followed in late years in the Greenwich Observations. The observed R.A. and N.P.D. of Vesta, Juno, Pallas, Ceres, are compared in 1834 and 1835 with those of the Daily Ephemeris for the neighbourhood of Opposition published in the *Nautical Almanac*; and no further step has been taken. For Jupiter, Saturn, and Uranus, from 1831 to 1833, the R.A. and N.P.D. have been interpolated from the *Berliner Jahrbuch*, using differences to the fourth order, the time for interpolation being previously corrected for planetary aberration. For the years 1834 and 1835 the Meridian Ephemeris of the *Nautical Almanac* has been used.

13. Tabular errors in R.A. and N.P.D. being thus found for every separate observation, groups are formed, and the mean of each class of errors is adopted as applicable to the mean time of the group. From these mean errors in R.A. and N.P.D., the mean errors in Geocentric Longitude and E.P.D. are found by use of the numbers P, Q, R, S, in the Appendix to the *Greenwich Observations* 1836. Then the errors in Heliocentric E.P.D., and the equations between the errors of Heliocentric Longitude and Radius Vector, are obtained as in Article 11.

A few observations are totally omitted which appear to have been made in unsatisfactory circumstances; and a few which give unsatisfactory results (distinguished by being inclosed in brackets) are omitted in the formation of means.

I have made no examination of the details of calculation which enables me to pronounce on their correctness; but I have great confidence in Mr. Breen's accuracy, and believe that these results may be accepted without question.

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