SELECTION CRITERION OF THE TRANSIT PLANETARY DATA

D. R. CONSTANTIN

Astronomical Institute of Romanian Academy
Str. Cutitul de Argint 5, 40557 Bucharest, Romania
Email: diana@aira.astro.ro

Abstract. Using the photographic data of Mercury's transits from 1970 and 1973, we compute in each moment of the transit intervals the differences between Mercury's geocentric angular distances *via* the rectangular topocentric planetary coordinates and Mercury's geocentric angular distances via Lagrange - Chauvenet reduction method. Based on these differences, we establish a data validation criterion which allows us to get better data quality after the eliminating the ones affected by refraction.

Key words: Transit planetary data, Celestial Mechanics, Solar System - Mercury.

1. INTRODUCTION

The transit photographic observations, all of the ground data, are affected by a lot of errors (e.g. refraction or random errors). Since some authors provide their observations in topocentric coordinates (Cristescu (1973), Schroll (1977)), while others give transit data exclusively in topocentric angular distances (Deviatkin (1988), Kiselev *et al.* (2005)), we try to find a method to use all these types of data. Moreover, we want to give a selection criterion of the observations to improve the data quality.

In Section 2, we present the data sources and reduction methods of these data. In Section 3, we compute and plot the differences coming from the geocentric angular distances of the two categories of data. Further, we use these differences to present a validation criterion of the reduced data and we discuss the results.

2. DATA AND REDUCTION METHODS

In this paper, for our purposes, we use observations of Mercury's transits over the solar disk on May 1970 (Cristescu, 1973) and November 1973 (Fiala *et al.*, 1976), (Schroll, 1977). The authors state the observations both in topocentric rectangular coordinates and topocentric angular distance.

In the first category of observations (in coordinates) in order to reduce the topocentric rectangular coordinates to the geocentric coordinates, we use the parallax method (Dinulescu, 1968):

Firstly, we compute the parallax corrections p_α, p_δ in α and δ to obtain Mercury's geocentric equatorial coordinates (α_g, δ_g) by means of the formulas:

$$\begin{aligned} \alpha_g &= \alpha_t + p_\alpha, \\ \delta_g &= \delta_t + p_\delta. \end{aligned} \tag{1}$$

Secondly, to obtain Mercury's geocentric angular distance values d_{co} at each transit moment - via the coordinates (α_g, δ_g), we use the formula:

$$d_{co} = \sqrt{((\alpha_g - \alpha_{gS}) \cdot \cos\delta_m)^2 + (\delta_g - \delta_{gS})^2}, \tag{2}$$

$(\alpha_{gS}, \delta_{gS})$ being the geocentric equatorial coordinates of the Sun and $\delta_m = \frac{\delta_g + \delta_{gS}}{2}$.

In the second category of observations (in distance) to reduce the topocentric angular distance to the geocentric angular distance d_{LC}, we use the Lagrange - Chauvenet method (Chauvenet, 1960):

$$d_{LC} \quad = \quad d_t + g \cdot \rho \cdot \cos\lambda, \tag{3}$$

where d_{LC} - the observed geocentric angular distance

d_t - the observed topocentric angular distance (in arc seconds)

$g = \pi - \pi'$, π / π' being horizontal equatorial parallax of Mercury / Sun

ρ - Earth radius of the observation place

(with respect to term $\cos\lambda$ see Chauvenet (1960)).

3. RESULTS

After reduction the topocentric data of Section 2, we compute and plot the differences $d_{co} - d_{LC}$ to evaluate the quality of the geocentric angular distances d_{co} and d_{LC}. We compute these differences for the transits: 1970 – observed by Cristescu, 1973 – observed by Fiala & Cristescu and also 1973 – observed by Schroll. Plotting the differences corresponding to these three observed transits, we clearly see a distinction between Schroll's data behavior and Cristescu's data.

In the Schroll case, all the differences in absolute value are $|d_{co} - d_{LC}| < 0.2''$ (see fig.3). But a discrepancy occurs in both cases of the first part of the transits observed by Cristescu, namely in 1970 (Cristescu, 1973) for the interval 5h - 9h (see fig.1), respectively in 1973 (Fiala & Cristescu) for the interval 7h-10h (see fig.2). Taking into account the Schroll's data behavior, namely for which all the differences state in the interval $[-0.2", 0.2"]$, we propose as a data validation criterion the elimination of Cristescu's transit observations for which the associated differences are $|d_{co} - d_{LC}| > 0.3''$ (see Clemence criterion (Clemence, 1943)).

Our explanation for the data which lead to the associated differences $|d_{co} - d_{LC}| > 0.3''$ (see fig.1 and fig.2), it is that the refraction and the other errors affect

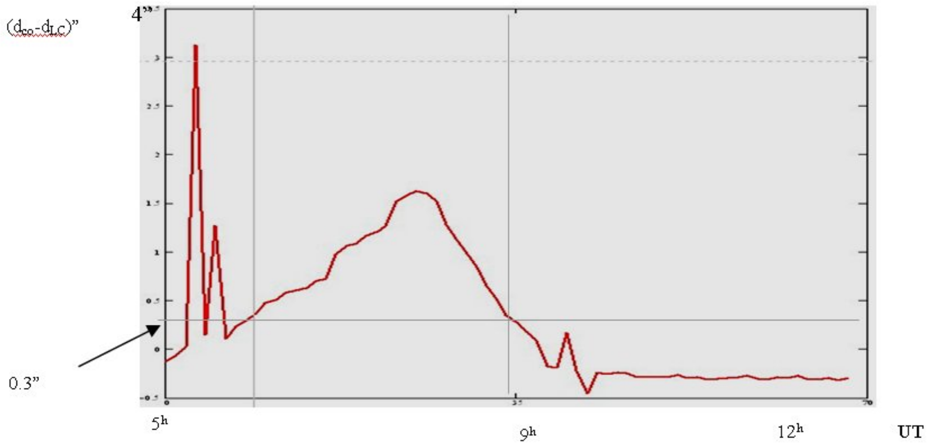

Fig. 1 – Graphical representation of the differences corresponding to Mercury transit observed by Cristescu on May 9, 1970.

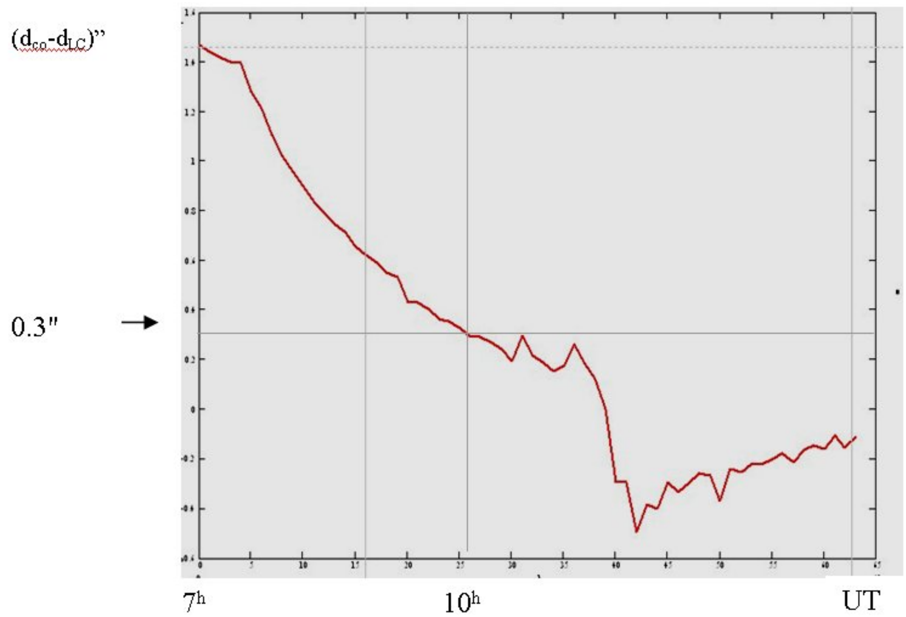

Fig. 2 – Graphical representation of the differences corresponding to Mercury transit observed by Fiala & Cristescu on November 14, 1973.

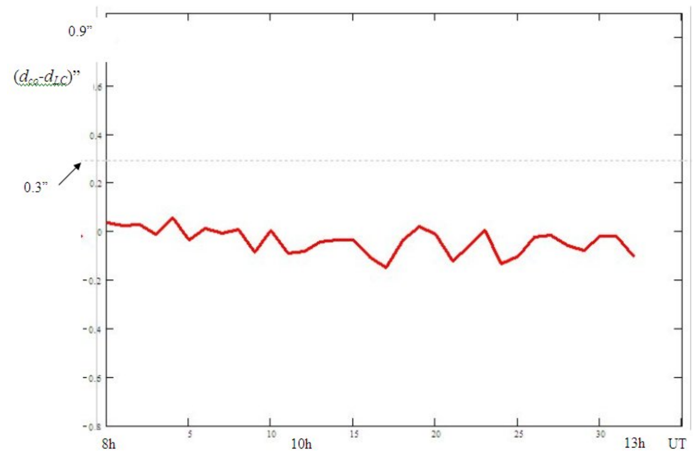

Fig. 3 – Graphical representation of the differences corresponding to Mercury transit observed by Schroll on November 14, 1973.

Cristescu's observations which is not the case at Schroll. We propose this data selection criterion which leads us to better data quality in order to use them further in various astronomical exploitations (*e.g.* the test of relativity (Constantin, 2013)).

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REFERENCES

Chauvenet, W.: 1960, Manual of Spherical and Practical Astronomy, Dover Publ., New York.

Constantin, D.: 2013, Test of relativity: Determination of Mercury's apsidal motion excess using transit photographic data, *Astronomische Nachrichten* **334**, 956.

Clemence, G. M.: 1943, The motion of Mercury 1765-1937, Astronomy Papers Am. Ephemeredes, 11, Part I, 13.

Cristescu, C.: 1973, *StCeAst* **18**, 151.

Deviatkin, A., V.: 1988, The Transit of Mercury over the Sun 13 November 1986, *Gao***UDC 520.8**, No 6357-B88.

Dinulescu, N.I.: 1968, Astronomie fundamentala, Ed. Didactica si Pedagogica.

Fiala, A.D., Cristescu, C.: 1976, *Astron. Astrophys.* **49**, 9.

Kiselev, A.A., Kiseleva T.P., Ismailov I.R., Mozhayev M.A., Kalinichenko O.A.: 2005, The Photographic Observations of Mercury transit in front of the Sun at 7 of May 2003 in Pulkovo with 26-inch Refractor, *RFBR*, Grant NO-04-02-16157.

Schroll, A.: 1977, *Astron. Astrophys.* **54**, 617.

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