

The contacts time in the transit of Mercury: a fitting procedure

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Sommario I tempi di contatto nel transito di Mercurio, vengono gestiti con una procedura di fitting che riduce l'effetto black-drop (goccia nera).

Abstract: The images of the transit of Mercury are affected by the atmospheric turbulence and by the black drop effect, due to the combination between the limb darkening function and the point spread function of the telescope (present also in space). The strategy is to use the data far from the black drop effect, before the internal contacts and to extrapolate from them the zero chord timing. As example we consider pure square root function data and the second contact of May 9, 2016 transit observed by Bijorn Kattendit.

Riassunto: Le immagini del transito di Mercurio sul Sole sono perturbate dal seeing atmosferico e dall'effetto 'goccia nera', dovuto alla combinazione tra l'oscuramento al bordo solare e la funzione di dispersione puntiforme dell'ottica del telescopio (questo effetto si manifesta anche da immagini prese dallo spazio, non perturbate dall'atmosfera). La strategia è di usare dati lontani dal momento dell'effetto goccia nera, prima dei contatti interni tra il disco di Mercurio e quello del Sole, ed estrapolare da quelli l'istante di tempo in cui la corda Mercurio-Sole sul disco di Mercurio vale zero.

Come esempio consideriamo dati simulati da pura radice quadrata, e dati dal secondo contatto (interno) del transito del 9 maggio 2016 osservati da Bijorn Kattendit.

Introduction: data from the previous transit

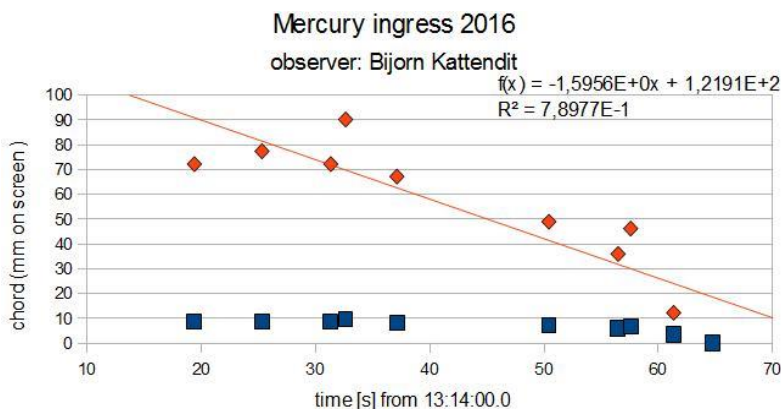
The forthcoming Mercury transit of November 11, 2019 is an opportunity to have another precise measurement of the solar diameter, having rather good images. As an example Bijorn Kattendit recorded the ingress of Mercury on May 9, 2016 with a Schmidt Cassegrain telescope of 280 mm f/10 and Barlow lens 2x. From each frame of the video; we measured the distance AB on the computer screen in mm and we read the timing of the video (it is 0.2 s ahead of UTC).

A table has been compiled from the video (available on youtube at Costantino Sigismondi channel, Mercury, Kattendit)

A linear fit of the data of the squared chord column yields the

equation $y = -1,5166 + 119,37 \cdot t$ which goes to zero for $t = 78.71$ s
Changing the last value of the chord from 3 mm to 0 mm (we are in the black drop phase) the equation changes to $y = -1,5956 + 121,91 \cdot t$ which goes to zero for $t = 76.40$ s
The average of the extrapolated zero chord time is 77.55 ± 1.15 s, corresponding to 11:15:17.35 UTC after the subtraction of 0.2 s of systematic error of the clock (declared by the observer).
The plot of the table of measured data is the following figure.

Fig. 1: data of the ingress of Mercury (internal contact) for 2016.



Time in local hour TMEC.

Comparison with the ephemerides

For the location of observation 48.98975 N 12.21593 E the expected time of the internal contact was 11:15:20.7 s UTC, then the contact occurred (3.35 ± 1.15) s, before the ephemerides time.
Considering that the ephemerides are very precise for what concerns the center of the planet and the center of the Sun; the only possible difference can be due to the radius of the Sun.
The actual dimension of the Sun, if the inner contact ends before the forecasted one, should be smaller.
Being the diameter of Mercury 12.1 arcseconds and being the

total calculated ingress time 191.2 s, the angular velocity of Mercury at the ingress was 6.33/100" per second.

Therefore the solar limb at the ingress point, in the direction of the path of Mercury was $\Delta p = 0.21 \pm 0.07$ arcseconds smaller. The reduction of the solar radius is obtained by multiplying Δp by $\cos(\alpha)$, with $\alpha \approx 30^\circ$ (see fig. 2)

$\Delta R = -0.18 \pm 0.06$ arcseconds

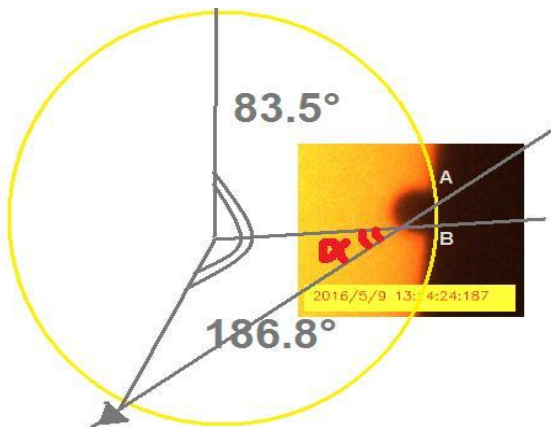


Fig 2: geometry of the transit of Mercury of May 9, 2016.

Conclusions

The evaluation of the contact time by using a fitting procedure is rather simple, and can be realized drawing a graphic and a linear fit (available with nearly all spreadsheet).

The operations required are 1) elevation to the power of 2 of the chord; 2) plot on graphic and drawing a fitting line to find the time of zero chord.

This operation can be done also on paper with a graphical procedure, by using a calculator without need of scientific

functions.

It is suitable to be used at school, in the first years of secondary school. It is the way of fitting a square root function, exploiting the fact that it is the inverse function of a parabola.

References

B. Kattendit, private communication

B. Kattendit, youtube, video

C. Sigismondi, F. Cardoso, Gerbertus 9 (2016)



Fig. 3 Black drop phenomenon in 2016, May 9th Mercury transit