

The solar diameter on 9 March 2016, from the total eclipse in Micronesia: at its standard value

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Abstract

The total eclipse of 9 March 2016 has been observed in Woleai atoll (Micronesia) by the Exploratorium team and posted in youtube. Exploiting the ghost images of that video we overcome the overexposition problems when dealing with the transition photosphere/chromosphere, dealing with Baily's beads around totality comparable with the intensity of the corona.

A correction to the standard value of the solar radius $R=959.63''$ of $\Delta R=+0.01''\pm 0.02''$ has been found, contrarily to the recent values near $960.0''$ with the last eclipses and transit of Venus. Perspectives for the measures to be done during the forthcoming transit of Mercury are drafted.

Introduction

The eclipse's timing of Halley (1715, who collected data from the Royal Society fellows who observed that eclipse in England) has been used to determine the solar diameter at that time (Fiala, et al. 1994). Since 1979 several eclipses have been observed with the purpose of monitoring the variations of the solar diameter exploiting the Baily's beads method (Sigismondi, 2009). The match between the lunar profile (Kaguya team, 2009) and the photospheric beads allows to compare directly the predictions with Occult 4.2 ephemeris software (Herald, 2016) with the observations.

We used the video of the 9 march 2016 total solar eclipse posted in youtube at 25 fps by the NASA/Exploratorium team, of which we determined the relative duration of the totality (no photospheric beads) to $\sqrt{2}$ frames of accuracy, i.e. 0.06 s.

Data collection and eclipse simulation

The youtube video has been downloaded and examined with

a software able to run it frame by frame: [4K Download](#).

The presence of ghost images before and after the totality allowed us to time accurately the disparition of the last Baily's bead before the totality and the apparition of the first one after the totality. Usually a camera with 8 or 16 bits of sensitivity, without appropriate filters, does not distinguish photosphere from chromosphere and inner corona because of saturation, with the impossibility to time appropriately beads' appearance.

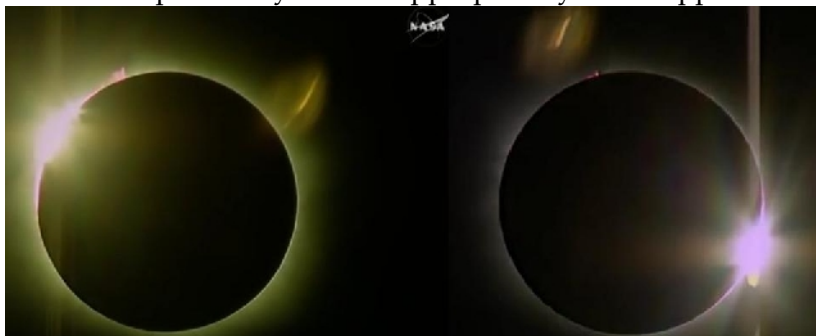


Fig. 1 The eclipse starts at Position Angle $PA=76.8^\circ$ (left) ends at 270° . The ghost images of the Sun crescents are opposite to their bright saturated homologous in the coronal background. Totality onset is with the ghosts equal to coronal luminosity.

The measured duration of the totality phase was 242.23 ± 0.06 s, the calculated duration of the totality was calculated by including the effects of lunar limb features and is 242.2 ± 0.05 s

The topocentric lunar diameter $0^\circ 33' 40.20''$ exceeded the solar one $32' 12.84''$ at the center of the eclipse of $87.36''$, covered in 250.1 s (circular lunar profile) at a velocity $\omega=0.3493''/\text{s}$.

The extra duration of the eclipse, with respect to the standard solar diameter's ephemerides, is $\Delta t=0.03 \pm 0.10$ s, corresponding to a correction $2\Delta R=\omega \cdot \Delta t$, so $\Delta R=0.01 \pm 0.02''$

Discussions of the data

This $\Delta R=0.01 \pm 0.02''$ measurement has been possible because the video was continuous and not assembled. The high quality of the images and the time resolution allowed to exploit the

visibility of the unsaturated ghost images with which we timed the totality of the eclipse. The Occult 4.2 software allowed us to recover the features of the lunar limb which determined the last beads around totality. The relative velocity of the Moon over the Sun $\omega=0.3493''/\text{s}$ has been calculated not including the lunar limb features, but using the duration of 250.1 s calculated by calsky.com for circular lunar and solar profiles, from $\text{PA}=237.1^\circ$ to $\text{PA}=64.2^\circ$, with $\Delta\text{PA}=172.9^\circ$ (near centerline). A different absolute timing between calsky.com and Occult 4.2. is due to the lunar profile features, namely a great large depression of $-2.5''$ (7.5 s) at $\text{PA}=270^\circ$. The location of Falealop is used as coordinates input for Occult4.2: it is the main island of the Woleai atoll, with the airplane track and routes and buildings.



Fig. 2 Folealop island is 0.7x 1 Km, in Woleai atoll, Micronesia.

If the observing position, generically declared as Woleai atoll, was different from the marked one by ± 10 Km, perpendicularly to the eclipse's centerline, the calculated totality duration changes ± 0.1 s, leaving our results valid. A displacement along the eclipse centerline does not change the totality duration within ± 100 Km by significant amounts.

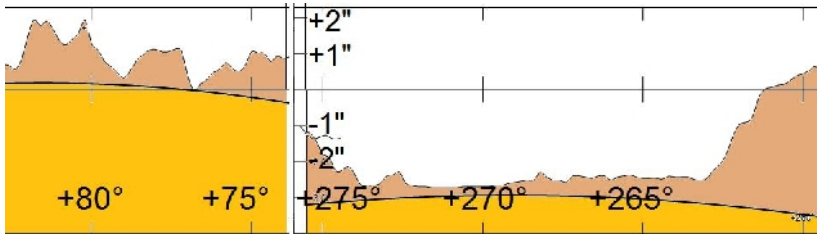


Fig. 3 The onset (left) of totality and the end (right), the Sun is below the lunar profile and it would shift left-right when the observer moves perpendicularly to the centerline. Horizontal scale $1^\circ=17.62''= 31,16 \text{ Km}$, vertical scale (enlarged) $1''=1,77 \text{ Km}$.

The agreement between this observation and the simulations with Kaguya lunar profile means that, within our errorbars, no variation of the solar diameter occurred: $R_\odot=959.64''\pm0.01''$. More observations of this eclipse would improve this result.

Perspectives for the next transit of Mercury

The solar diameter measured with Mercury (Emilio, et al. 2012) will exploits the 2016 ingress of this transit, lasting 191.0 s and a spherical Sun. The ephemerides of the Sun and of Mercury are more accurate than the lunar ones. Due to solar parallax of $8.8''$ (the Earth's diameter seen from the Sun) a displacement of a few Km on the Earth does not change the duration of the ingress, but only a solar ΔR affects it. Mercury is a $12.06''$ disk, the velocity $\omega=0.063''/\text{s}$ allows an accuracy of $\pm0.06''$ with $\pm 1\text{s}$ in time, obtainable by extrapolating the length of the chord Sun-Mercury to zero to find internal and external contacts timings, avoiding the black drop effect, due to instrumental optics coping with solar limb darkening.

References

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