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A Comparison of the Black-Drop Effects during the Transits of Mercury in 2016 and Venus in 2004–2012

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Abstract

The black-drop effect during the 2016 transit of Mercury against the Sun has been observed and photographed by amateur astronomers in Dorval (Montréal, Canada), confirming that the black drops of Mercury and Venus are produced by the halos observed around the planets and the Sun, because of the imperfect optical resolution of the instruments used. The differences between the black drops of Mercury and Venus are due to the differences in size between the halo and the diameter of the planets.

Résumé

Le phénomène de la goutte noire a été observé et photographié pendant le transit de Mercure de 2016 devant le Soleil par des astronomes amateurs de Dorval (Montréal, Canada), confirmant que les gouttes noires de Mercure et Vénus sont dues aux halos observés autour des planètes et du soleil en raison de la résolution optique imparfaite des instruments utilisés. Les différences observées entre les gouttes noires de Mercure et Vénus sont attribuables à la différence de taille entre le halo et le diamètre des planètes.

1. Introduction

The transit of Mercury against the Sun of 2016 May 9 has been observed and photographed by members of the Dorval Astronomy Club (CDADFS). The characteristics of the black-drop effect have been compared to those observed during the transits of Venus in 2004 and 2012 and reported by the CDADFS in this Journal (Duval et al., 2005, 2012) and on its website (Dorval Astronomy Club), in good agreement with other published observations (Pasachoff, 2012;, Schneider et al., 2004).

2. Instrumentation, Methods and Observations

The instrument used by R. Sauvé was a 90-mm TopCon Telephoto with a focal length of 500 mm at *f*/5.6 and *f*/8, equipped with a Nikon camera. The size of pixels in this camera was ~2.5 arcseconds (206 x 6.1/500). Throughout this article, arcseconds will be indicated as ″.

The characteristics of the black drop of Mercury have been measured from photos of the contact point taken with this instrument, using the same methods as in the case of Venus (Duval et al., 2005, 2012).

Photos of the black drops of Mercury and Venus, taken at contact points with instruments of comparable resolution and producing similar widths of halos around the planets, are presented in Figure 1, where different magnifications have been used to facilitate visual comparisons (the actual diameters of Mercury and Venus during these transits were 12″ and 54″, respectively, according to the Observer's Handbook of The Royal Astronomical Society of Canada (RASC) of 2016 and 2004.

3. Results and Discussion

As observed and explained during the transits of Venus (Duval et al., 2005, 2012), the photos of Mercury and Venus in Figure 1 are composed of:

- the bright disk of the Sun in the upper background,
- the dark black sky in the lower background,
- an apparent inner black disk of the planets in the foreground,
- a continuous halo of greyish colour around the apparent inner black disk of the planets, located above and inside the real disk of the planets, and due to the bright light of the Sun blurring over and inside the planets,
- a similar halo between the bright disk of the Sun and the black sky, located above the sky,
- a black-drop effect in between the inner black disk of the planets and the black sky.

In the case of Mercury, around the continuous greyish halo, there is also an outer layer containing isolated pixels not continuously connected to one another. More generally, the boundaries between the various components of Mercury, the Sun, and the sky are not as sharp as in the case of Venus.

This is because of the small diameter of Mercury, requiring higher magnifications and resulting in images of pixels in the photos that are large (~2.5″) compared to the diameter of the planet (~12″). As a result, pixels are not always located entirely above one component (e.g. the inner black disk), but partially above it and partially above the continuous halo/real disk of the planet. The same occurs at the boundaries between the continuous halo and the outer layer, and between the bright disk of the Sun, the black sky, and the halo in between.

Furthermore, this crossover of pixels above these components changes from one photo to the other, since the planet is moving across the Sun and across the grid of pixels in the camera. Such photographic conditions can also produce variations of intensity between pixels, in regions where contrast is weak and near detection limits, e.g. in the outer layer.

Taking into account these effects, and also the well-documented value (RASC, 2016) of the real diameter of Mercury as a yardstick (12″), it has been determined that the diameter/size of the various components in the photos of Mercury are;

- for the outer layer: between ~8 pixels (~20″) away from contact point, and ~6 pixels (~15″) at contact point (G. St-Onge),
- for the continuous halo/real disk: ~5 pixels (~12″),
- for the apparent inner black disk: ~3 pixels (~8″),
- for the black drop: ~1 pixel (~2″).

These values, as well as the other characteristics of the black drop of Mercury, are indicated in Table 1, with the terms used in Table 1 indicated below the table. Also indicated in Table 1 are the characteristics of the black drop observed previously with Venus (Duval et al., 2005, 2012), using an instrument of similar resolution producing a similar width of the continuous halo, as deduced from Figure 3 of Duval et al. (2012) related to the transits of Venus of 2004 and 2012.

A schematic representation of the black-drop effects of Mercury and Venus is indicated in Figure 2, based on Table 1 and Figure 1. As in Figure 1, different scales are used in Figure 2 for Mercury and Venus to facilitate visual comparisons.

It thus appears that, as in the case of Venus (Duval et al., 2005, 2012):

1) the black-drop effect during the transit of Mercury is due to the formation of a continuous halo around the planet and the Sun, because of the imperfect optical resolution of the instrument used, as explained in detail in Figure 2 of ref. (Duval et al., 2012).

2) the apparent inner black disk of the planet Da appears visually smaller than its real disk D, because of the halo produced over and inside the planet by the Sun. Similarly, the apparent bright disk of the Sun, including the halo around it, appears visually slightly larger than its real disk.

The black drop of Mercury, however, appears bigger (S in Table 1), longer (L/Da) but narrower (W/Da), than the black drop of Venus.

Table 1: Characteristics of the black drops of Mercury and Venus

Years of Transit	Mercury	Venus	
	2016	**2004 – 2012**	**Units**
D	12	54	″ (arcseconds)
H	2	2	″
Da	8	50	″
L	2	2	″
W	2.2	24.5	″
S	9	2.5	″
L/Da	25	4	%
W/Da	27	49	%

(see below for definition of terms used)

D	Diameter of the real disk of the planets on the day of transit, from RASC *Observer's Handbooks*.
H	Width of the continuous halo around the apparent inner black disk of the planets (over and inside the real disk), and of the halo around the Sun above the sky, from photos.
Da	Diameter of the apparent inner black disk of the planets, from photos.
L	Length of the black drop, perpendicular to the disks of the planets and the Sun, from photos.
W	Width of the black drop, tangentially to the disks of the planets and the Sun, from photos.
S	Surface of the black drop at contact point, divided by surface of the apparent inner black disk of the planets, from photos.

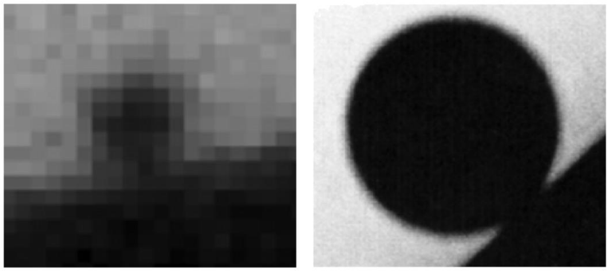

Figure 1 — Photos of the black drops of Mercury and Venus, using instruments of similar resolution (~2″). Different magnifications are used for Mercury and Venus in this Figure (actual diameters of the planets were 12″ and 54″, respectively)

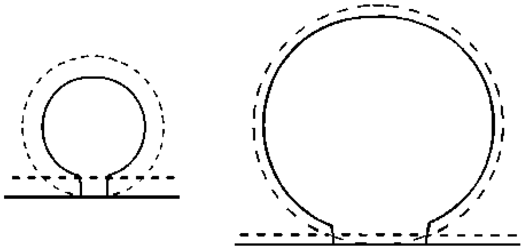

Figure 2 — Schematic representation of the black drops of Mercury and Venus. Different scales are used for Mercury and Venus in these graphs (actual diameters D were 12″ and 54″, respectively)

This is in apparent agreement with observations made during the transits of Mercury on 1999 November 15, and Venus on 2004 June 8, by the *Transition Region and Coronal Explorer* (TRACE) spacecraft (Schneider, Pasachoff, 2012; et al.). The differences between the black drops of Mercury and Venus, however, are more difficult to see with high-resolution telescopes such as the one used by TRACE (<1″) because they produce much smaller and fainter black-drop effects, as explained in Duval et al., (2005, 2012).

These differences between the black drops of Mercury and Venus are essentially due to the relative size of the continuous halos compared to the diameter of the planets (H/Da or L/Da), and are not affected in practice by the actual and exact position of the real disks D of the planets against the Sun (dotted lines).

4. Conclusions

The black-drop effect with both Mercury and Venus is due to the formation of halos around the planets and the Sun because of the imperfect optical resolution of the instruments used.

The black drop of Mercury, however, appears to be visually bigger, longer, and narrower, compared to the diameter of the planet, than the black drop of Venus.

This difference is due to the smaller diameter of Mercury for a similar size of halo and resolution of instrument used. ✶

References

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