SIZE OF BLACK DROP EFFECT VS. RESOLUTION OF TELESCOPES DURING THE TRANSITS OF VENUS OF 2012 AND 2004

BY MICHEL DUVAL*, MARC BRAULT, ANDRÉ GENDRON, JEAN-MARIE GOHIER, GILLES GUIGNIER, GILBERT ST-ONGE*, RICHARD SAUVÉ, MARJOLAINE SAVOIE, ALEX STEFANESCU, FRANK TOMARAS AND YVES TREMBLAY

Amateur Astronomy Club of Dorval (CDADFS)
*Also members of RASC and Club of Montreal (SAM)
duvalm@ireq.ca,

ABSTRACT. The black drop effect (BDE) during the 2012 transit of Venus (ToV) against the Sun has been photographed by amateur astronomers in Dorval (Montreal, Canada), confirming that the BDE is produced by the optical halos observed around Venus and the Sun at contact points. A quantitative relation between the size of the BDE and the optical resolution of the telescopes used is presented.

RÉSUMÉ. Le phénomène de la goutte noire (PGN) pendant le transit de Vénus (TdV) de 2012 devant le Soleil a été photographié par des astronomes amateurs à Dorval (Montréal, Canada), confirmant que le PGN est produit par les halos optiques observés autour de Vénus et du Soleil aux points de contact. Une relation quantitative entre la taille du PGN et la résolution optique des télescopes utilisés est présentée.

1. INTRODUCTION

The transits of Venus (ToV) against the Sun in June 2012 and 2004 have been observed by a large number of amateur and professional astronomers around the world. Extensive investigations by amateur astronomers on the "black drop effect" (BDE) during the ToV of 2004 in Dorval have been published in the JRASC by Duval *et al* (2005). It was shown that the BDE can be explained very simply by the disappearance of the optical halos inside Venus and outside the Sun at contact points.
This paper investigates further the relation between the size of the BDE and the optical resolution of the telescopes used in 2012 and 2004.

2. INSTRUMENTATION

The amateur telescopes used in Dorval to take photographs of the BDE in 2012 were: an 8-inch, F/4 Celestron (M.Brault); a 200 mm, F/10 Celestron (R.Sauvé); a 6-inch Newton (A.Stefanescu); an 80 mm, F/7 refractor (Y.Tremblay), a 80 mm Celestron refractor (F.Tomaras-1) and a 300 mm telephoto camera (F.Tomaras-2).
A photograph taken in 2012 by the Solar Dynamic Observatory (SDO) and available on its website was also used in this paper for comparison.

3. RESULTS AND DISCUSSION

Photographs of the BDE taken by the SDO, Y.Tremblay, M.Savoie, F.Tomaras-1, M.Brault, R.Sauvé, A.Gendron, J.M.Gohier and F.Tomaras-2, at contact II of 2012 or contact III of 2004 in Dorval, are presented in Figure 1, respectively from left to right and top to bottom.

In the previous investigation (Duval *et al* 2005), it was shown that the optical halos observed around Venus in the photographs are mostly due to the imperfect resolution of the telescopes used, and that the contribution of the "solar limb darkening effect" (Pasachoff 2012) to the formation of the halos and the BDE is significant only with professional telescopes of very high resolution, not with amateur telescopes of relatively low resolution.

It was shown that these halos are "blurring" from the bright Sun into the dark disk of Venus and into the dark sky. The apparent black disk of Venus in the photographs is thus smaller than the real disk of Venus, which actually corresponds to (the apparent disk of Venus PLUS the internal halo around Venus). Similarly, the apparent bright disk of the Sun in the photographs is larger than the real disk of the Sun, which corresponds to (the apparent bright disk of the Sun MINUS the external halo around the Sun). The relative position of the apparent and real disks of Venus and the Sun were shown in 2005 to explain the BDE.

A schematic representation of the halos and BDE observed in 2004 in Dorval around Venus and the Sun at contact III (egress of Venus from the Sun) is indicated in Figure 2. This representation is a schematic but accurate reproduction of the photographs taken in 2004. The apparent disks of Venus and the Sun are represented by a black line, and the real disks by a dotted line. The halos are located between the black and dotted lines.

In Figure 2, immediately after the real disk of Venus has come in contact with the real disk of the Sun ("Real contact IIIa"), a portion of the real disk of Venus is above the sky and not any more above the Sun ("Contact IIIb"). The halos around this portion of Venus and the Sun therefore disappear, and this portion appears as black. This causes the BDE, which increases in size at "Contact IIIc" and even more so at "False contact IIId" (which corresponds to the contact between the apparent disks of Venus and the Sun). The BDE then disappears as Venus continues its way into the sky and leaves the Sun.

The same explanation applies to the halos and BDE observed in 2012 in Dorval at contact II (ingress of Venus into the Sun) but in reverse order, starting from "False contact IId" up to "Real contact IIa".

It was also shown in 2005 that the width of the halos around Venus and the Sun can easily be calculated by comparison to the real size of Venus, available for example in the "Observer's Handbook" of the RASC (58.2 arcseconds in June 2004). Also that the width of the halos can be used to evaluate the optical resolution of the telescopes used, providing values that are very similar to those based on the “point-spread function” of professional astronomers. The optical resolution of the telescopes used in this paper and thus calculated is indicated in arcseconds in Figure 1.

Photographs in Figure 1 correspond to contacts IIc of 2012 and IIIc of 2004 as defined in Figure 2. They have been adjusted to provide approximately the same visual diameter for (the apparent black disk of Venus + its halo) in Figure 1. The apparent black disk of Venus thus appears smaller, as it indeed is, in photographs taken with telescopes of lower resolution.

The lower the resolution of the telescope, the larger the halos around Venus and the Sun and the larger the BDE. This has been quantified by calculating the surface of the BDE in the photographs of 2012 and 2004, and by expressing it in Figure 3 as a % of the surface of the apparent black disk of Venus, as a function of telescope resolution.

4. CONCLUSIONS

The photographs taken in Dorval during the Transit of Venus (ToV) of 2012 confirm the observations made during the ToV of 2004. They indicate that the “black drop effect” (BDE) is mostly due to the optical halos appearing around Venus and the Sun because of the imperfect resolution of the telescopes used. A quantitative relation between the size of the BDE and the resolution of the telescopes used during the ToVs is presented.

REFERENCES

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RASC’s Observer’s Handbook for Year 2012 and 2004
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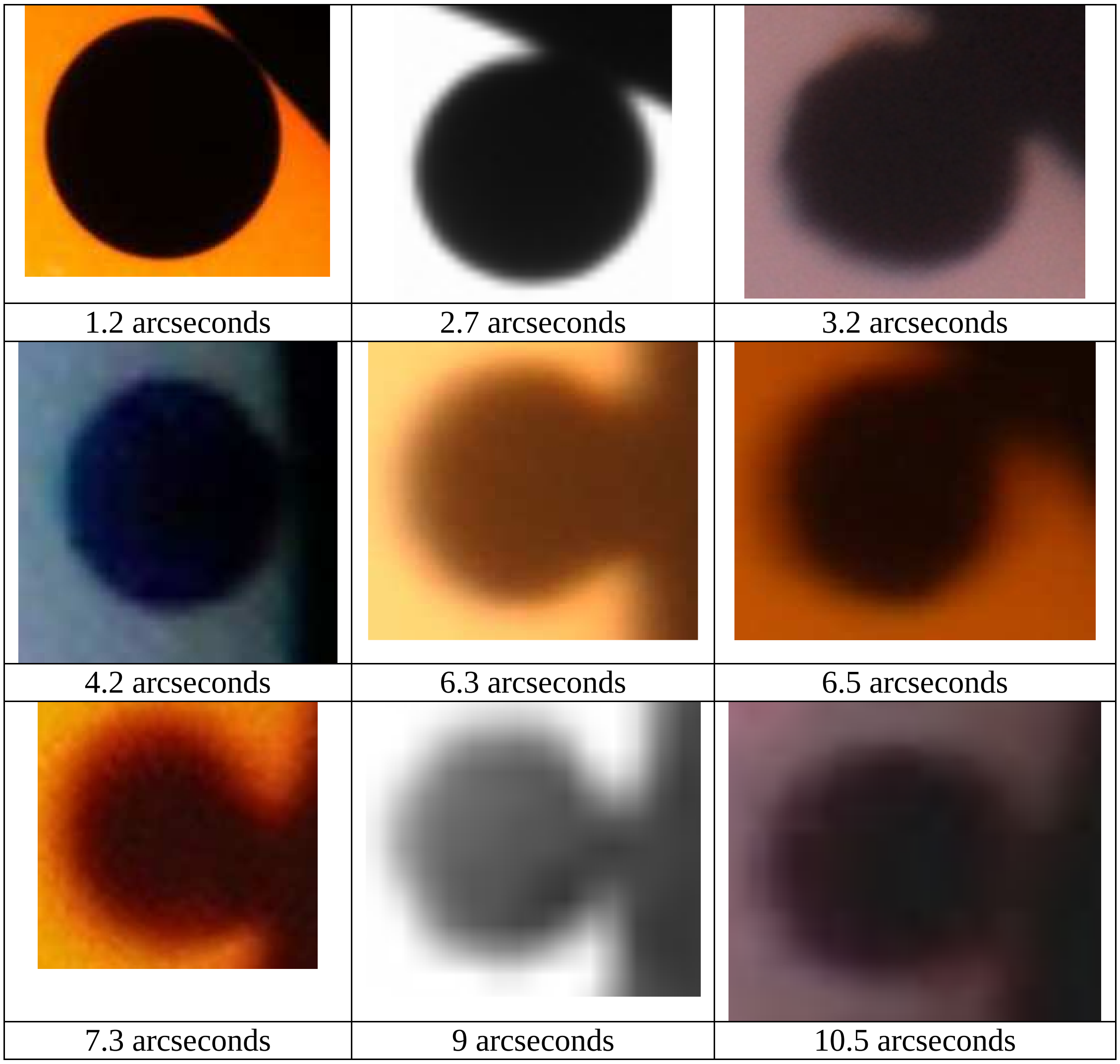

FIG.1 – Photographs of the BDE during the ToV of 2012, taken by the SDO, Y.Tremblay, M.Savoie, F.Tomaras-1, M.Brault, R.Sauvé, A.Gendron (ToV of 2004), J.M.Gohier and F.Tomaras-2, respectively from left to right and top to bottom.

The resolution of the telescopes used is indicated in arcseconds, as deduced from the width of the halos around Venus and the Sun.

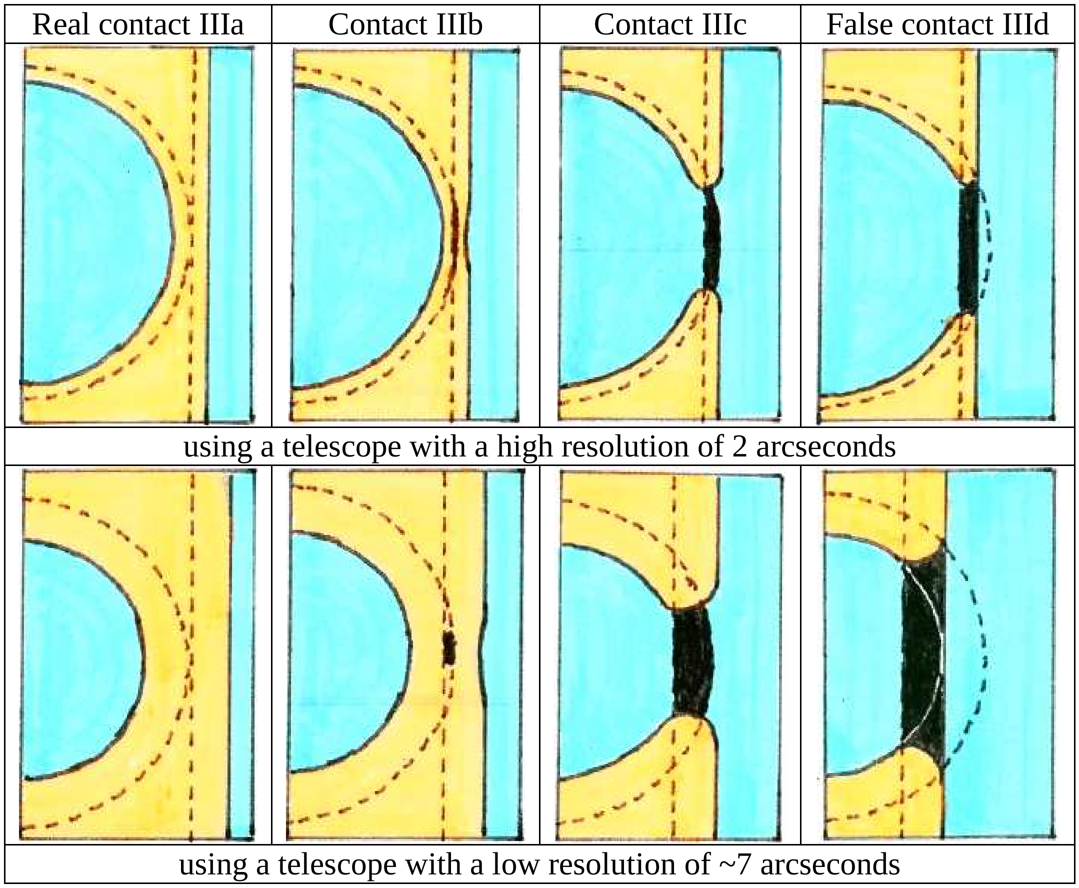

FIG. 2 – Schematic representation of the halos around Venus and the Sun, and of the BDE during contact III of the ToV of 2004 in Dorval, using telescopes of relatively high (2 arcseconds) and low (~7 arcseconds) resolution.

Dotted lines = real disks of Venus and the Sun.

Black lines = apparent disks of Venus and the Sun in telescopes.

Color codes: yellow = apparent disk of the Sun; blue = apparent disk of Venus and sky beyond the Sun (both are actually black); black = BDE as seen in telescopes.

This schematic representation also applies to contacts IId to IIa of the ToV in 2012 in Dorval.

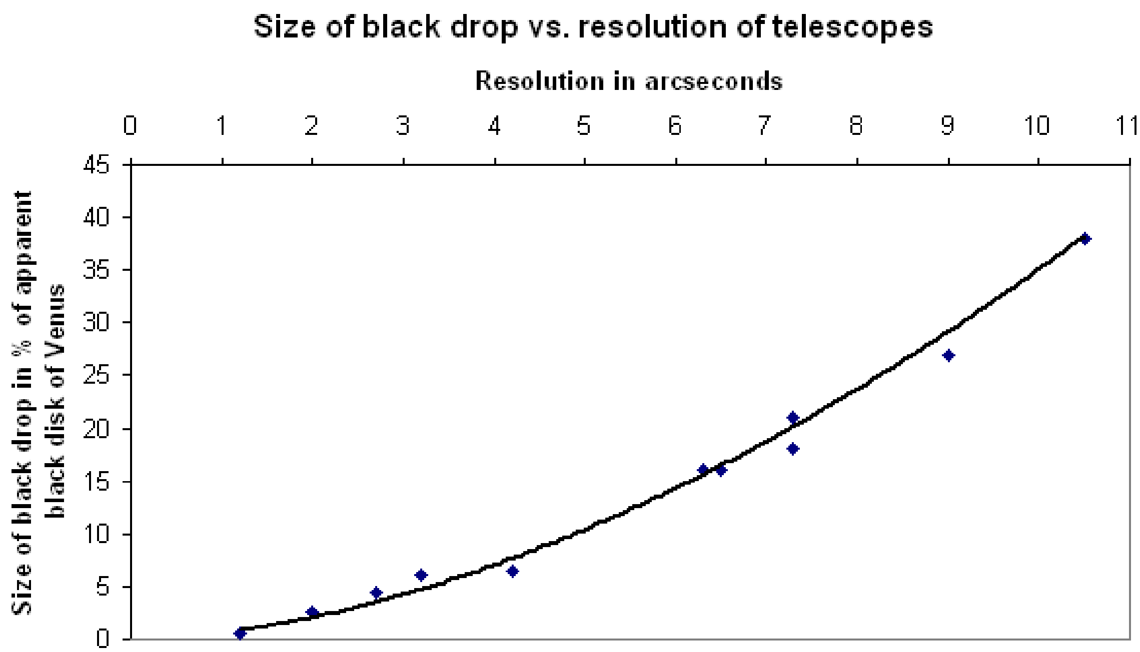

FIG. 3 – Size of the black drop (expressed as a % of the surface of apparent black disk of Venus) vs. resolution of the telescopes used, from photographs taken by the SDO, G.Guignier, Y.Tremblay, M.Savoie, F.Tomaras-1, M.Brault, R.Sauvé, A.Gendron, A.Stefanescu, J.M.Gohier and F.Tomaras-2, respectively from left to right in the Figure.