CCD Photometry of the occultation of star 2UCAC 33233154 by asteroid (511) Davida on May 7th 2010

Tsamis, V.[1,2,3], Tigani, K.[2]

[1] International Occultation Timing Association – European Section, http://www.iota-es.de, e-mail: vtsamis@aegean.gr
[2] Sparta Astronomy Association, http://www.spartastronomy.gr
[3] Ellinogermaniki Agogi Observatory, Dimitriou Panagea Str., Pallini Attikis, 15351 Athens, Greece

Abstract

We present a positive CCD observation and data reduction results of the occultation of star 2UCAC 33233154 (Vmag = 13.2) by asteroid (511) Davida (Vmag = 11.5) on May 7th 2010, which we made at Ellinogermaniki Agogi Observatory, near Athens, Greece.

1. Introduction

In observing asteroidal occultations, the most convenient situation for the observer is that both the target star magnitude and the magnitude drop during the occultation are large enough, so that the event can be easily captured on video using sensitive low-light video cameras. In this way, GPS time inserting devices can also be used for recording the precise UT times of disappearance and reappearance of the star. In cases where the target star is faint or when the magnitude drop is small, the observer needs either a large aperture telescope (which is often not available) or another method of observation, in order to capture the event successfully. The most suitable method for capturing these faint targets - low magnitude drop events is the CCD observation. Precise photometry can then be carried out in order to reveal the parameters of the occultation event. The case of the observation of the May 7th 2010 Davida occultation, which is presented here, is such a case.

Figure 1: CCD image of the asteroid and the star 20 minutes before the predicted time of the occultation. The asteroid is brighter than the star.

2. The Davida Event - Scientific Prediction

The prediction data we used for the observation had been published by Steve Preston on April 29th 2010 at: http://www.asteroidoccultations.com/2010_05/0507_511_23201.htm. On 2010 May 07 UT, the 326 km diameter asteroid (511) Davida was expected to occult 2UCAC 33233154, a 13.2 mag star in the constellation Virgo, for observers along a path across S Europe and SW Asia. A large part of Greece was well inside the predicted path. During the occultation the combined light of the asteroid and the star would drop by only 0.21 mag; from 11.29 to 11.5 mag (the magnitude of the asteroid). The predicted maximum duration of the occultation was 21.9 seconds, depending on the impact parameter of each observing site with respect to the asteroid's centre of figure.

3. Location and Equipment

The observation of the Davida event was made at the Ellinogermaniki Agogi School Observatory (EAO), which is located in Pallini, 15 km east of the city of Athens, with a 40 cm f/10 Meade LX200-R Schmidt Cassegrain telescope. The geographical coordinates of the EAO are: LAT 37° 59' 52.3” North, LON 23° 33' 56.0” East, ALT 162 m (from Google Earth). For CCD imaging we used an ATIK 16-HR camera, which has the following technical specifications:

Chip	Sony Chip ICX-285 AL
Resolution	1390 x 1040 pixels (1.445.600 pixels)
Chip size	10.2mm x 8.3mm - diagonal 13.15mm
Pixel size	6.45 x 6.45 um
Digitization	16 BIT
Computer Port	USB 1.1 Download time max. 15s
Cooling	Peltier cooling (25° below ambient temp.)
Preview function	Only approx. 1 second download time
Protective glass	Optical glass – BK-7

Table 1: CCD specifications

4. Timing

Since accurate timing is very important in capturing occultation events, we synchronized our laptop computer clock with an Oregon Scientific RMB 899P DCF77 radio clock a few minutes before the predicted time for the event.

5. Method of Observation

Our purpose was to acquire enough photometric points in order to produce a well defined light curve of the occultation event. It was thus important that both the exposure time and the CCD download (read-out) time were kept as short as possible. The maximum pixel value of the target (star & asteroid) and all reference stars (Fig. 2) should lie in the linear region of the CCD detector for the differential aperture photometry measurements that would follow the observation; in our case: between 20,000 and 30,000 ADU for our 16-bit camera. In order to achieve this, we started observation one hour before the event, acquiring many CCD images for testing.

Finally, we chose a high-binning mode (4x4) and used sub-framing, which proved to be an ideal solution. We took a series of 3 sec exposures, with a rate of 1 exposure every 4 seconds; read-out time was 1 second. During the actual observation we acquired 161 images. UT time of first exposure was 23:12:56 and UT time of last exposure was 23:23:53. Immediately after the observation we took dark frames. Throughout the night, atmospheric transparency and star image stability were very good. Almost no wind was blowing, temperature was about 16 °C.

6. Data reduction: Processing of photometric points with MaximDL, AIP4WIN and IDL software

The images were photometrically reduced using standard techniques (Henden & Kaitchuck 1990; Howell 2006; Warner 2006). We calibrated all the images using dark subtraction, no flat fielding was applied. Then we proceeded with photometric measurements using MaximDL software (Fig. 3). Signal to noise ratio of the target (star & asteroid) was above 300. Maximum pixel value of the target prior to and after the occultation was about 25,000. FWHM value was 2.6 arc seconds (Fig. 4).

For the differential aperture photometry we used two nearby stars in the field as reference stars: 2UCAC 33233159 was the comparison star and 2UCAC 33233148 was the check star. In the MaximDL aperture photometry window we set the star aperture radius to 6 pixels, the sky annulus inner radius to 8 pixels and the sky annulus outer radius to 10 pixels.

Figure 2: Choice of reference stars

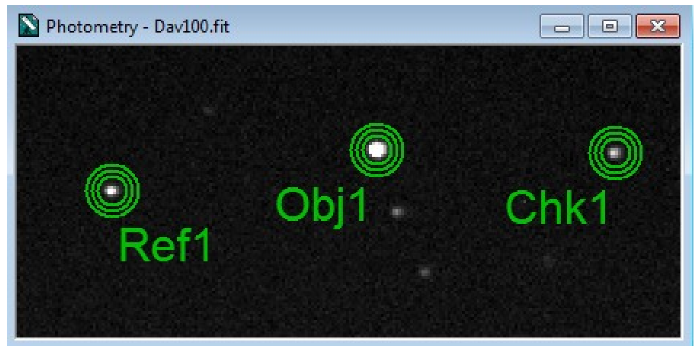


Figure3: Differential aperture photometry targets

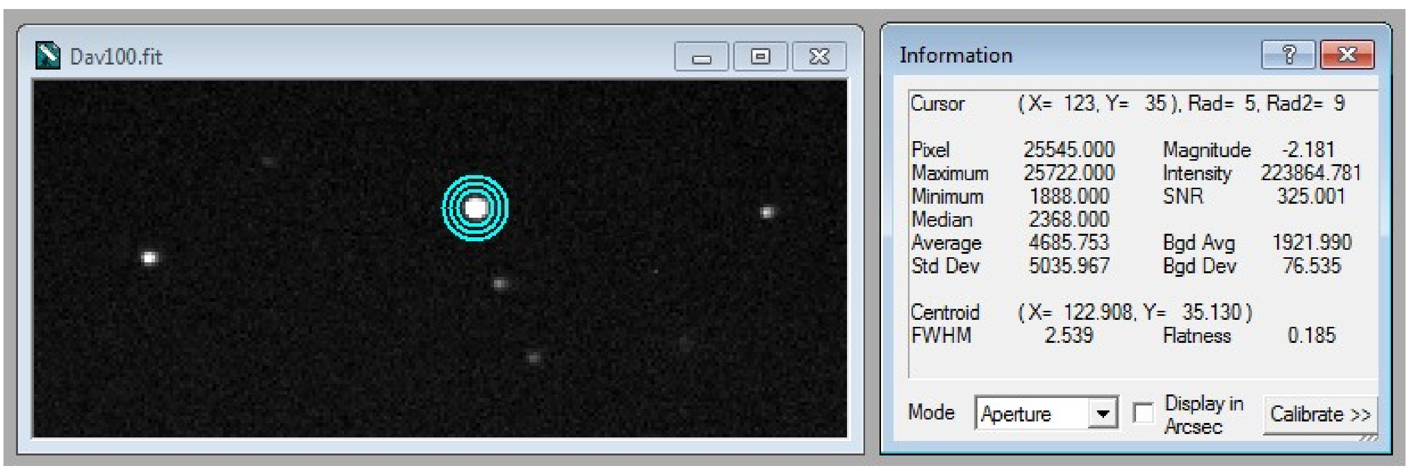
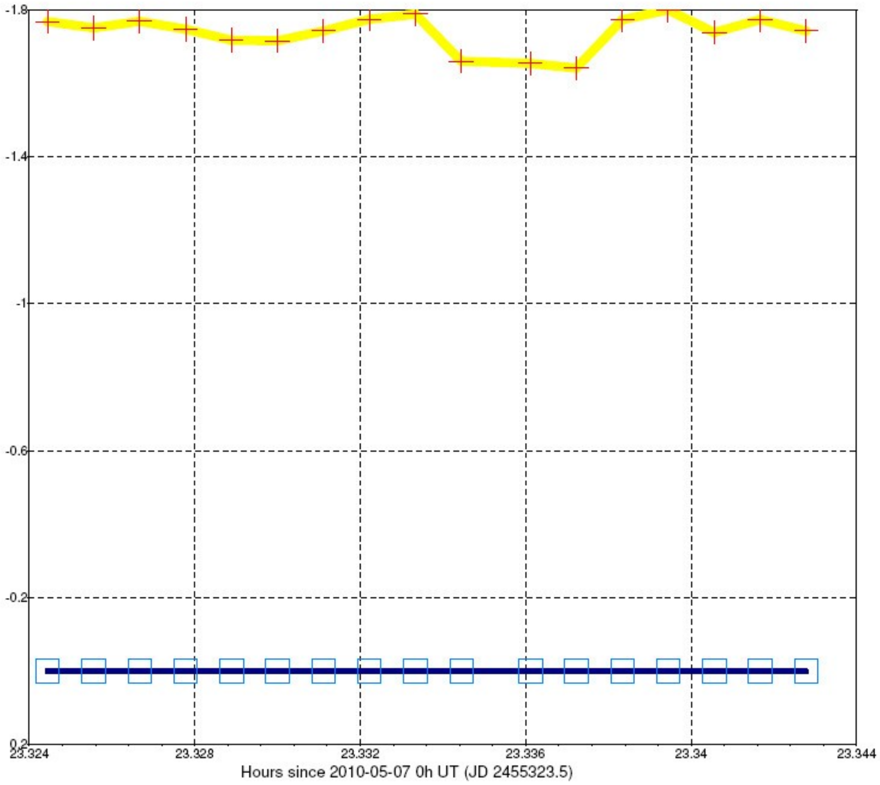


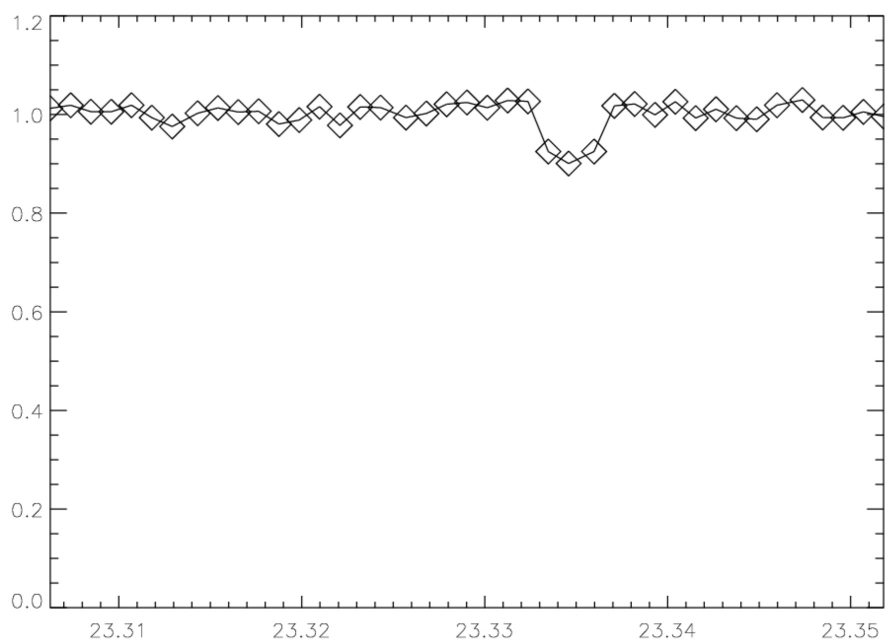
Figure 4: Some technical information about the star image and sky quality

The photometry processing clearly showed that in three of the images there is a relatively small but well defined flux drop of the target, in accordance with the prediction and during the expected time of the event. Namely, these image files were: Dav104.fit, Dav105.fit and Dav106.fit (to be discussed later). This was also obvious at the light curve plot which was produced (Fig. 5 A). In order to double check these results we did another run at the observation data using slightly smaller photometric aperture radii: 5,6 & 8 pixels respectively, a method first proposed by Howell (Howell, 1953), who suggests using the minimum aperture radii possible. The results were the same. Finally, in order to verify the consistency of the results with other processing tools, we made photometric measurements with AIP4WIN software (Astronomical Image Processing for Windows, Version 2.1.10, Berry & Burnell, 2006). Again, the results were the same, indicating that in these three images the actual occultation of the star by asteroid Davida was captured.

Apostolos Christou independently processed the CCD images with Interactive Data Language (IDL) software at Armagh Observatory. The photometric light curve which was produced (Fig. 5 B) is in full accordance with the ones we produced by using MaximDL and AIP software.



A



B

Figure 5: Light curves of the occultation event with MaximDL (A) and IDL (B). In both plots, which were independently acquired, the same set of three images shows a considerable flux drop.

7. Results

From the time stamp in the headers of the FIT files, we examined the UT times in relation to the event, as follows:

Dav103.fit - Time UT = 23:19:55 [start of exposure, no flux drop]
Dav103.fit - Time UT = 23:19:58 [end of exposure, no flux drop]
Dav104.fit - Time UT = 23:19:59 [start of exposure, flux drop]
Dav105.fit - Time UT = 23:20:03 [start of exposure, flux drop]
Dav106.fit - Time UT = 23:20:08 [start of exposure, flux drop]
Dav106.fit - Time UT = 23:20:11 [end of exposure, flux drop]
Dav107.fit - Time UT = 23:20:12 [start of exposure, no flux drop]

From these times and taking into account that the CCD read-out time was 1 second, we estimate that:

- Disappearance was at UT 23:19:58.5 +/- 0.5 seconds
- Reappearance was at UT 23:20:11.5 +/- 0.5 seconds
- The duration of the event was 13 seconds +/- 1 second
- The time of mid-event was at: UT 23:20:05 +/- 0.5 seconds

Acknowledgment

We would like to thank Apostolos Christou for his valuable advice in using this observation method and for his independent reduction and analysis of the data.

References

Berry, R. & Burnell, J."The Handbook of Astronomical Image Processing", Willmann-Bell, 2nd edition, 2006.
Henden, A. & Kaitchuck, R. "Astronomical Photometry", Willmann-Bell, 1990.
Howell, S.B. "Handbook of CCD Astronomy", Cambridge University Press, 2nd edition, 2006.
Howell, S.B. "Two-dimensional aperture photometry: Signal-to-Noise ratio of point-source observation and optimal data-extraction techniques", Publications of the Astronomical Society of the Pacific, vol. 101, June 1989, p. 616-622.
Warner, B.D. "Lightcurve Photometry Analysis", Springer, 2006.