TYC 6223-00442-1 Duplicity Discovery from Occultation by (52) Europa

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Abstract: The occultation of TYC 6223-00442-1 by the asteroid (52) Europa observed on 2012 August 12 in Belo Horizonte, Brazil, showed this star to be a double system. The magnitude of the primary component is estimated to be 11.3 ± 0.1, and the magnitude of the secondary component is estimated to be 12.4 ± 0.1. Since the occultation was observed from only one station it was not possible to derive a unique solution to position angle and separation. The four solutions presented in this paper were obtained considering an asteroid shape model.

Observation
On 2012 August 12, Giacchini observed the occultation of TYC 6223-00442-1 by the asteroid (52) Europa from Belo Horizonte, Brazil. According to the prediction, Belo Horizonte was placed 71 km from the central line. The predicted occultation path and observing site are shown in Figure 1. The maximum predicted duration was 81.4 s with a magnitude drop of 1.4.

The observation was made using an 18-cm-aperture clock-driven Newtonian telescope, a Watec 902H2 Ultimate camera and a KIWI-OSD time inserter. The occultation was recorded on digital tape. The light curve obtained (Figure 2) shows two flux drops. Table 1 displays the observatory position, and Table 2 contains the times of the events. The occultation of star A had a duration $D_A = (78.78 \pm 0.04)$ s, while star B was $D_B = (59.3 \pm 0.2)$ s.

TYC 6223-00442-1 was not listed in the Fourth

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Figure 1: Predicted path and occultation details [Herald, 2012]. Belo Horizonte is marked in red.

Figure 2: Star's light curve from 1:23:56 to 1:26:58 UT.
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Interferometric Catalog, nor in the Washington Double Star catalog.

Data analysis

The derivation of the double star parameters that follows are based on [Herald et al. 2010] and were carried out using Occult4.1.0 [Herald, 2012]. Since the occultation was observed from only one station, it is not possible to ensure if our observatory was on the north or on the south of the central line. Nor is it possible to distinguish whether the secondary star was on the same side of the asteroid as the primary star. If we consider the asteroid to have a spherical shape, this leads to four different solutions of the pair's position angle and separation.

The asteroid (52) Europa has mean diameter of \( \delta = (350 \pm 5) \) km, according to AcuA [Usui et al. 2011]. We combined this information with the asteroid profile at the moment of the occultation (Figure 3) [Marciniak et al. 2012] in order to find the possible solutions for the double star parameters. For each of the four possibilities described before, we considered two situations: one in which the asteroid profile could inscribe a circle of diameter \( \delta \), the other in which the profile is almost entire contained in such a circle. The first situation supposes the asteroid to be a little larger than the AcuA's mean diameter, while the second considers that the asteroid was a little smaller.

For each of these we derived the pair's separation and position angle. Since the asteroid profile was quite spherical, we expect that between these two extreme situations (i.e. in intermediate scales for the profile), separation and position angle would remain between those two values. This allows us to make an estimative of the double star parameters for each of the four possible situations. The graphical reductions are shown in Figures 4-7 and the solutions are presented in Table 3.

Occult's magnitude calculator routine [Herald, 2012] allowed us to determine the magnitudes of both stars in view of the brightness levels of the light curve (Figure 2). According to UCAC4 Catalog [Zacharias et al. 2012], the (combined) visual magnitude of TYC 6223-00442-1 is \( \text{V-Mag} = (10.943 \pm 0.003) \).

In order to avoid natural flux fluctuations interference, we calculated the average of the brightness during a period of time close to the flux drop. Thus, we considered six levels of brightness, shown on Table 4. This results in two measurements of the stars' mag-

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Figure 4-7: Double star graphic reduction of separation and position angle using ISAM profile model. The circle corresponds to the AcuA mean diameter of 350km. The predicted occultation is indicated by the pink line. Figures on the left consider the asteroid profile at the moment of the occultation to be a little larger than the mean diameter; while figures on the right consider that it was a little smaller. Figures 4 and 6 show the solutions assuming that the shadow's path was closer to the predicted one; the other two represent the solution further from the predicted path.
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Magnitudes: disappearance steps lead to the values 12.43 and 11.26; and reappearance figures are 12.42 and 11.26. Assuming an asymmetric occultation (i.e. the sequence of the stars involved on the events was B-A-B-A), the resulting magnitudes are: MagA = (11.3 ± 0.1) and MagB = (12.4 ± 0.1).

Based on the data presented in this report, the double star characteristics are:

<table>
<thead>
<tr>
<th>Star</th>
<th>Tycho-2 6223-00442-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UCAC2 146-109152</td>
</tr>
<tr>
<td></td>
<td>UCAC4 364-078961</td>
</tr>
</tbody>
</table>

Coordinates (J2000)
RA 17h00m36.877s  Dec -17°13’46.22” [UCAC4]

V-Mag A 11.3 ± 0.1
V-Mag B 12.4 ± 0.1

Separation and Position Angle: Possible solutions shown in Table 3.

References
Herald, D., 2012, Occult4.1.0.8, software.