

Stellar occultations by (3451) Mentor, an irregular Trojan

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Abstract. Trojan objects are small bodies that orbit in the Lagrange points of a given object. The Jupiter Trojans, in particular, have a very important scientific interest as their origin may be linked to the dynamic evolution of the giant planets. Therefore, the physical characterization of these small bodies would help to better understand the formation and evolution of the Solar System. (3451) Mentor is among the largest Trojans, having an estimated diameter of 126 km. To better characterize this object, we provide predictions of stellar occultations promoted by this body. Four stellar occultation events were recorded during the years 2019, 2020, and 2021, two of them were single chords, one had two chords, and the last one was detected by three different locations. The multi-chord observations allowed a precise determination of the size and shape of this object. Single-chord events allowed for obtaining accurate astrometric positions, which is useful for improving predictions for future events. We will present at this work the results obtained from the analysis of those occultations. In particular we will show the detection of a two-drop event, that raises the possibility for this body to be binary.

Resumo. Objetos troianos são pequenos corpos que orbitam nos pontos de Lagrange de um dado objeto. Os Troianos de Júpiter são de grande interesse científico já que a sua origem está possivelmente ligada à evolução dinâmica dos planetas gigantes. Sendo assim, a caracterização física destes pequenos corpos deve ser buscada para melhor restringir os modelos de formação e evolução do Sistema Solar. (3451) Mentor está entre os maiores Troianos, tendo um diâmetro estimado em 126 km. A fim de melhor caracterizar este objeto, disponibilizamos predições de ocultações estelares por ele promovidas. Quatro eventos de ocultações estelares foram registrados durante os anos de 2019, 2020 e 2021, sendo duas delas de corda única, uma detecção de duas cordas e outra com observações positivas de três locais diferentes. As observações multi-cordas permitiram melhor determinar tamanho e forma do objeto. Já as observações de corda única fornecem posições astrométricas acuradas, que são úteis para a predição de eventos futuros. Apresentaremos neste trabalho os resultados obtidos da análise destas ocultações. Em especial mostraremos a detecção de uma curva de luz com duas quedas, que levanta a possibilidade de que este seja um objeto binário.

Keywords. Occultations – Minor planets, asteroids: individual: Mentor – Astrometry – Techniques: photometric.

1. Introduction

A stellar occultation occurs when an object passes in front of a star for a given observer. The observer can register a drop in the flux of the target star over a period of time. These events allow obtaining precise information about the occulting body's physical properties, such as size and shape, and to sound its vicinity.

In this work we provided predictions and made observations of stellar occultations by (3451) Mentor during the years of 2019, 2020, and 2021, resulting in 9 observations, from which 7 were positives. Mentor is a Jupiter Trojan located at Lagrange L5 point, discovered by Antonín Mrkos at Klet' observatory in 1984 (Klet' Observatory 1984), and has an equivalent radius measured in infrared of 63 km (Grav et al. 2012).

2. Methodology

From the records of stellar occultation events, we obtained the flux of the occulted star and of some reference stars in the field over time. After that, we divide the flux of the target star by a reference star to eliminate any sky transparency variations, such as the passage of clouds. Then the result is normalized and plotted over the time of each frame, which is denominated the occultation light curve (Fig. 2).

The normalized light curve is then compared to a model, which considers the occultation by an opaque body, the Fresnel diffraction, the stellar diameter, and the exposure time of the data, in order to obtain the immersion and emersion times of the occultation. This process was made using the Stellar occultation reduction and analysis (SORA) software (Gomes-Júnior et al. 2022).

By obtaining the immersion and emersion times of the event we can determine the event duration, which can be combined with the objects' velocity to calculate the size of the observed chord from each site. All the chords of a given event are combined to obtain the size and shape of the body.

3. Results and Discussions

Single-chord events were useful to obtain a better astrometric position of the body, making the following predictions more reliable, thus having higher chances to present two or more positive detections.

The September 2019 event resulted in 3 positive observations, where we obtained the limb shape of the body represented in Fig. 1, in this case, the occultation showed an elliptical limb for Mentor, the parameters of the adjusted ellipse can be found in Tab. 1.

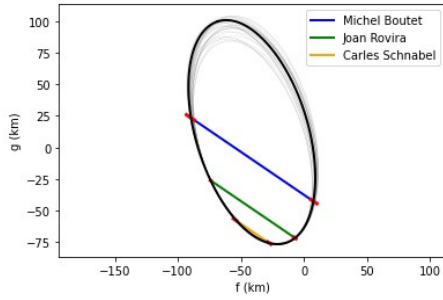


FIGURE 1. Each different color line represents the occultation chord observed at different locations, the red bar at the extremities of each chord represents the uncertainty related to them, and the ellipse represent in black shows the best adjustment found for the shape and size of the body during the occultation.

TABLE 1. Parameters obtained for the adjusted ellipse on September 2019 event. The equivalent radius obtained for this case is close to 63 km, obtained with infrared observations.

Equatorial Radius	88 ± 5 km
Equivalent Radius	62.23 ± 5.40 km
Oblateness	0.50 ± 0.03
Position angle	$73^\circ \pm 3^\circ$

On the October 2021 event, we obtained 2 positive observations and 1 negative. In this event, the light curve provided by the observer Matthieu Conjat presented two drops on the flux of the target star, which can be viewed in Fig. 2. The chords obtained on this event are illustrated in Fig.3, showing the fractions of the body sounded by each observer.

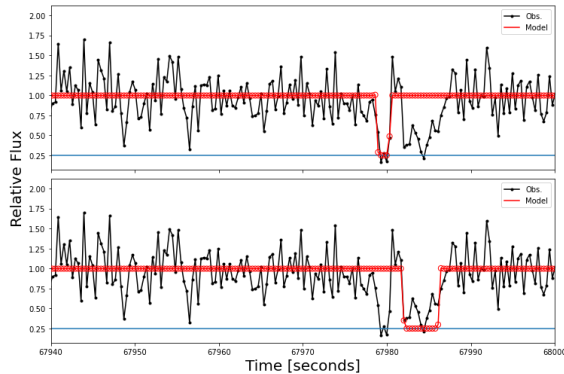


FIGURE 2. Light curve from the observer Matthieu Conjat where it's possible to identify two different drops on the flux of the target star. Each panel shows the fit for each drop, providing a double-chord detection.

With the provided data, it is not possible to define Mentor's shape. The two-drop chord can indicate a binary object or a large topography feature on Mentor's limb. A visual fit of two circles is shown in fig. 4 to give an idea of each component size.

4. Conclusions

From the analysis of the occultations, it is clear that (3451) Mentor is an irregular object. Its shape could not be obtained due to the double chord detection on the 2021 event. This Trojan object can have a large topographic feature, or be a binary system. In any of those cases, this rises scientific interest in this object. New stellar occultations and rotation light curves may be used in the near future to fully characterize its size and shape.

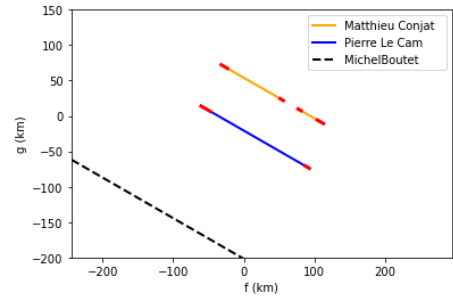


FIGURE 3. Chords obtained for October 2021 event, where we can see the duplicity on Conjat's chord, and the single chord from Pierre's observation. The negative observation from Michel Boutet is also represented in this figure.

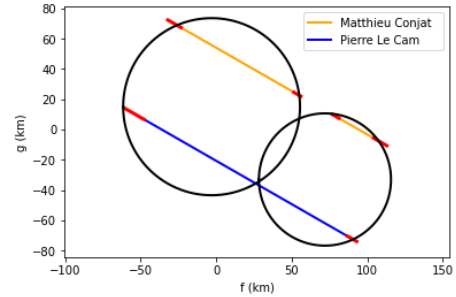


FIGURE 4. Visual adjustment for October 2021 event supposing a binary object. In this case, it could be a contact binary or two components orbiting each other.

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