

STELLAR OCCULTATIONS OF THE LUCY MISSION TARGETS OBSERVED IN FRANCE IN 2022

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Abstract. As part of the development of a network of observers of stellar occultations by asteroids, we present our first results from observation campaigns carried out in 2022. The objects observed were the asteroids (15094) Polymele, (3548) Eurybates and (21900) Orus, targets of the LUCY mission. These observations were realised as part of a collaboration with the South West Research Institute. This document presents the observations performed by the network and preliminary results of these occultations.

Keywords: Occultations, Minor Planets, Asteroids, Methods : observational, Pro-am collaboration

1 Introduction

Stellar occultation is a powerful technique to get access to physical characteristics of small solar system bodies. This technique requires to observe the event on a thin band (large as the body) with multiple stations (telescope, camera and timing system). More stations are involved, more details on physical characteristics of the body are obtained. In that context, an equipped and trained network of observers is a clear advantage, in particular, thanks to the amateur community.

As part of the API pro-am, initiated by the Paris Observatory and following a first occultation expedition to Spain (Schnabel et al. 2022) (for the Lucy probe), we start to develop and equip a French team of occultation observers (Desmars et al. 2022). This team was made possible by the Commission des Techniques en Astronomie Amateur (CT2A) of the Société Astronomique de France (SAF, <https://saf-astronomie.fr/techniques-astronomie-amateur/>).

Following previous experiences in occultations, we identify that the need is to be organised and to offer high-quality dating equipment. In this context, we were funded by the Paris Observatory ProAm initiative in early 2022 for the purchase of Timebox (i.e. dating system). This document presents the four different campaigns of occultations we organised in France in 2022, involving targets of the LUCY mission.

These observations were realised as part of a collaboration between the South West Research Institute (PI Marc Buie - stellar occultation team), Paris Observatory (PI Josselin Desmars - Co-PI François Colas) and French national structures, the Société Astronomique de France (Commission CT2A - PI Thierry Midavaine) and the Association Française d'Astronomie (Section Sciences Participatives - PI Guillaume Langin - Co-PI Marie Grand).

2 The occultation events in France for 2022

The Lucy mission is a NASA spacecraft that will visit 6 trojan asteroids in 2027 and 2033. Stellar occultations are helpful to determine physical characteristics and position of these objects before the mission and in order to prepare their flybys. In that context, several occultation campaigns of these targets are organised all over the world by M. Buie (SWRI), the Lucy occultation project leader.

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In 2022, four occultations by these targets were visible in France and we decided to take part of the campaign to train and prepare the French network. In addition, as the Eurybates occultation involving a relative bright star accessible to small telescopes or even DSLR, we have encouraged a large public from beginners to professional to participate. Thus, we have organised several webinars* presenting occultation and the way to observe it. At the same time, we set up a centralised data feedback system so that we could then have an overview of the results.

For the four occultations, we present preliminary analysis. All the data were collected by M. Buie (SWRI) who is leading the scientific analysis and who is in charge of publishing the results in forthcoming papers. Consequently, our results are partial and we only provide shape profile without dimension as an example of results that we obtained from these occultations.

2.1 Polymele 26/08/2022

The first occultation took place on August 26 and involved Polymele that occulted a magnitude 12.8 star. Polymele is a 29km-size trojan and it has a satellite, provisionally named Shaun, discovered during an occultation a few months earlier (Buie et al. 2022). In addition to Polymele, the secondary objective was to detect also the satellite. The occultation was visible in Portugal, Spain and France (Fig. 1 left). In addition to the main campaign in Portugal, 3 stations observed this occultation in France leading to 2 positive and 1 negative. These chords allow to obtain the ellipsoid shape profile of the asteroid (Fig. 1 right). The Northern chord shows a double event probably due to topographic features at the surface of the body. 7 other stations could have observed, but the sky was cloudy (no data). The satellite Shaun was not detected during this observation campaign.

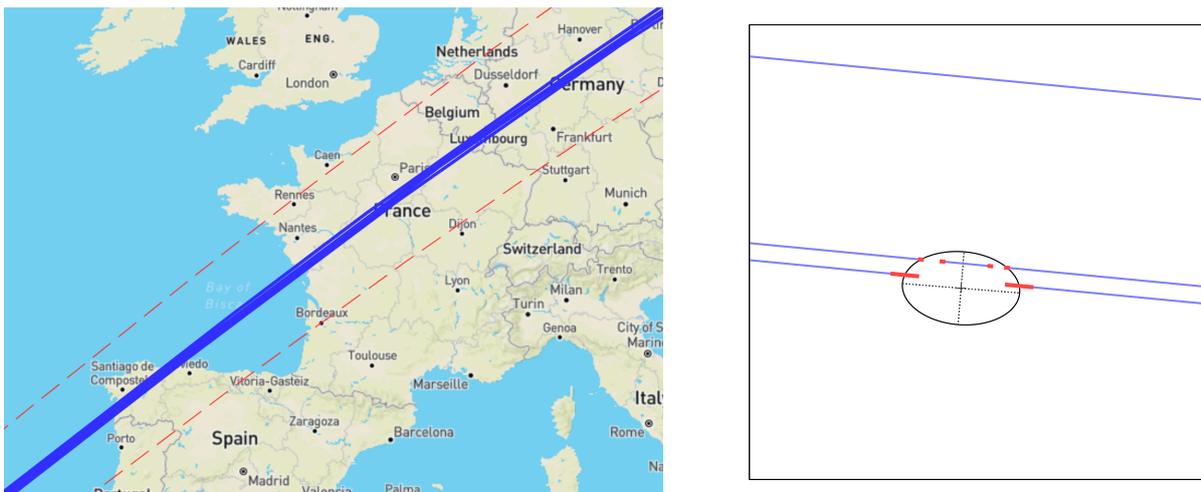


Fig. 1. Left: Occultation map by Polymele on 26/08/2022. Blue lines represents the body limits whereas the red lines represent the uncertainty on the path. **Right:** Shape profile of Polymele derived from the occultation assuming an ellipsoid.

2.2 Eurybates 23/10/2022

The second occultation involved Eurybates, a 64km-size trojan occulting a magnitude 8.7 star on October 23 (Fig. 2 left). This event was very interesting because of the brightness of the star making the occultation recordable with a small telescope or even a small telelens. For this occultation, AFA organised a huge campaign for the amateur community with the rallying of about 1000 observers. At the end, 340 persons made a report and because of bad weather all along the path most of them were under clouds. Despite the bad weather, the occultation was positive for 17 stations and negative for 44 stations. The preliminary analysis of the occultation

*See for instance, the AFA Youtube channel: <https://www.youtube.com/watch?v=Eo3hDbQLaVA>, <https://www.youtube.com/watch?v=8mQ7M-QRRxw> and <https://www.youtube.com/watch?v=SZTLtN0QuT8>

allows to derive the shape of Eurybates at the time of the occultation (Fig. 2 right). For this analysis, Eurybates is assumed to be an ellipsoid whereas it is irregular, in particular some topographic features are revealed by the Southern positive chord. Note that, as for the other occultations, results are preliminary.

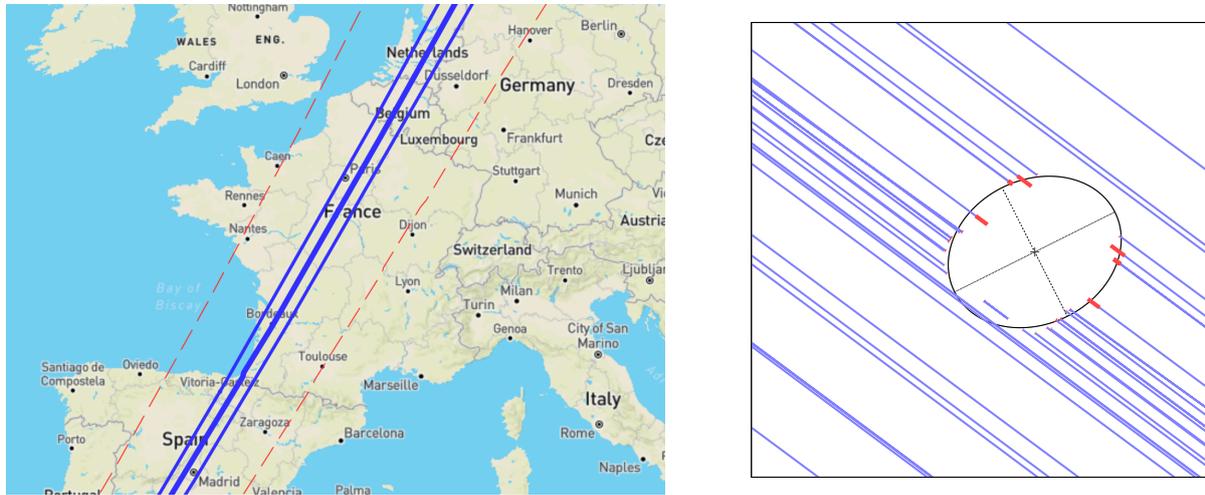


Fig. 2. Left: Occultation map by Eurybates on 23/10/2022. **Right:** Shape profile of Eurybates derived from the occultation assuming an ellipsoid.

2.3 Orus 16/12/2023

The third occultation was Orus, a 53km-size trojan, occulting a magnitude 14.8 star on December 16 (Fig. 3 left). The occultation was recorded on 12 stations with 9 positive and 3 negative. A preliminary analysis of the occultation allows to derive the shape profile presented in Fig. 3 right. The profile is done assuming an ellipsoid for Orus, whereas Orus is clearly irregular.

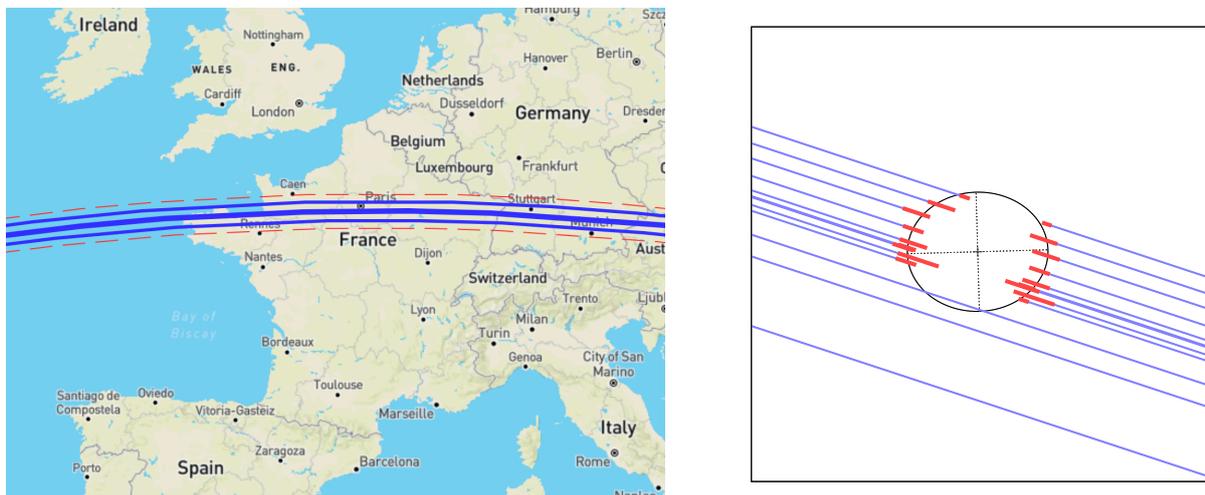


Fig. 3. Left: Occultation map by Orus on 16/12/2023. **Right:** Shape profile of Orus assuming an ellipsoid derived from the occultation.

2.4 Polymele 27/12/2023

The last event involved again Polymele that occulted a magnitude 14.4 star on December 27 (Fig. 4 left). Due to weather conditions, only one station reported a positive chord. Using one chord, we can only assume a spherical body with a specific size in order to derive the two possible solutions that fit to the chord (Fig. 4 right)

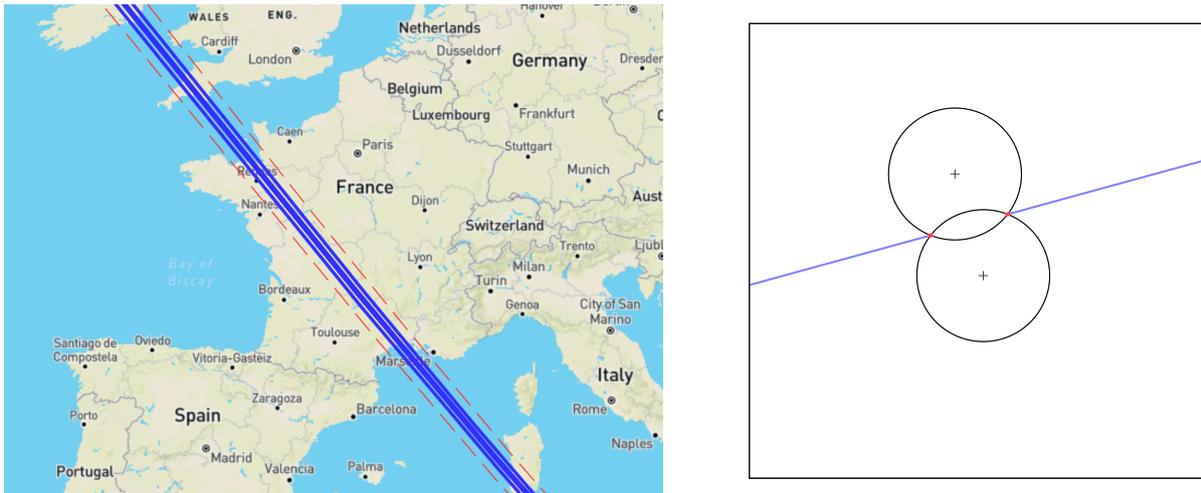


Fig. 4. Left: Occultation map by Polymele on 26/08/2022. Right: Shape profile of the two possible solutions derived from the occultation, assuming a spherical body.

3 Conclusions

In 2022, we organised and participated to four occultation campaigns in collaboration with the SouthWest Research Institute. They were all impressive success in term of coordination, participation and scientific results. This is validating the network we are developing. Thanks to the API PromAm initiative of Paris Observatory, we are equipping the amateur community for timing system, camera, etc. that are required to record high quality data of occultations. We have collected the data of the four campaigns and they will be analysed in details and scientific results will be published by the Lucy occultation project. All these occultations will help in a better knowledge of the Lucy targets and in the preparation of the flybys by the probe in 2027 and 2033.

We would like to thank all the observers who took part in these observation campaigns, as well as the Société Astronomique de France and the Association Française d’Astronomie. We would also like to thank Marc Buie for his predictions. We would also like to thank the Observatoire de Paris-PSL for its support in our Pro-Am collaboration, and the SF2A for allowing us to present our results during the Semaine Française de l’Astrophysique 2023.

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