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Background

Jupiter trojans are two main asteroid groups sharing Jupiter's orbit— L4 and L5 (Fig 1). These two groups are 60° ahead and 60° behind Jupiter as it orbits the Sun. They are of interest because they give insight into the early solar system.

An occultation is when an object moves in between a celestial object, in this case a star, and our viewing position on Earth. This completely blocks the light coming from the star, causing it to blink out for the duration of the passage. As a result, this casts a shadow of the asteroid over the Earth, which can be measured to learn about the object's size and shape. Each occultation duration at each latitude is combined to make a sketch of what the object looks like (Fig 3). We can use both the duration and the size of the occultation in order to learn more about the size and shape of the object we are observing.

In October 2021, NASA launched a spacecraft called Lucy, named after the early hominid fossil which provided a deeper understanding of human evolution. Lucy will fly out to Jupiter's orbit and study its trojans¹. In October of 2022, Lucy was gravity assisted by Earth and is now heading out towards its first target, a main belt asteroid Dinkinesh.²

Lucy team did an occultation of Polymele on March 27, 2022 to get better estimates of its size and orbit.² Trailing behind it was the shadow of a potential satellite asteroid. The satellite, nicknamed Shaun, measures 5 km in diameter and is about 200 km away from Polymele.³

To confirm the existence of Shaun, and to gather additional data on Polymele itself, the Lucy mission organized a campaign of over 200 people spanned over 100 km to observe another occultation on February 3rd, 2023, which we attended.

References

- 1.NASA. The Lucy Spacecraft and Payload. Retrieved from <https://www.nasa.gov/content/lucy-spacecraft-and-payload>
- 2.Southwest Research Institute. Timeline. Retrieved from <https://lucy.swri.edu/timeline.html>
- 3.NASA. (2022, August 16). NASA's Lucy Team Discovers Moon Around Asteroid Polymele. Retrieved from <https://www.nasa.gov/feature/goddard/2022/nasa-s-lucy-team-discovers-moon-around-asteroid-polymele>

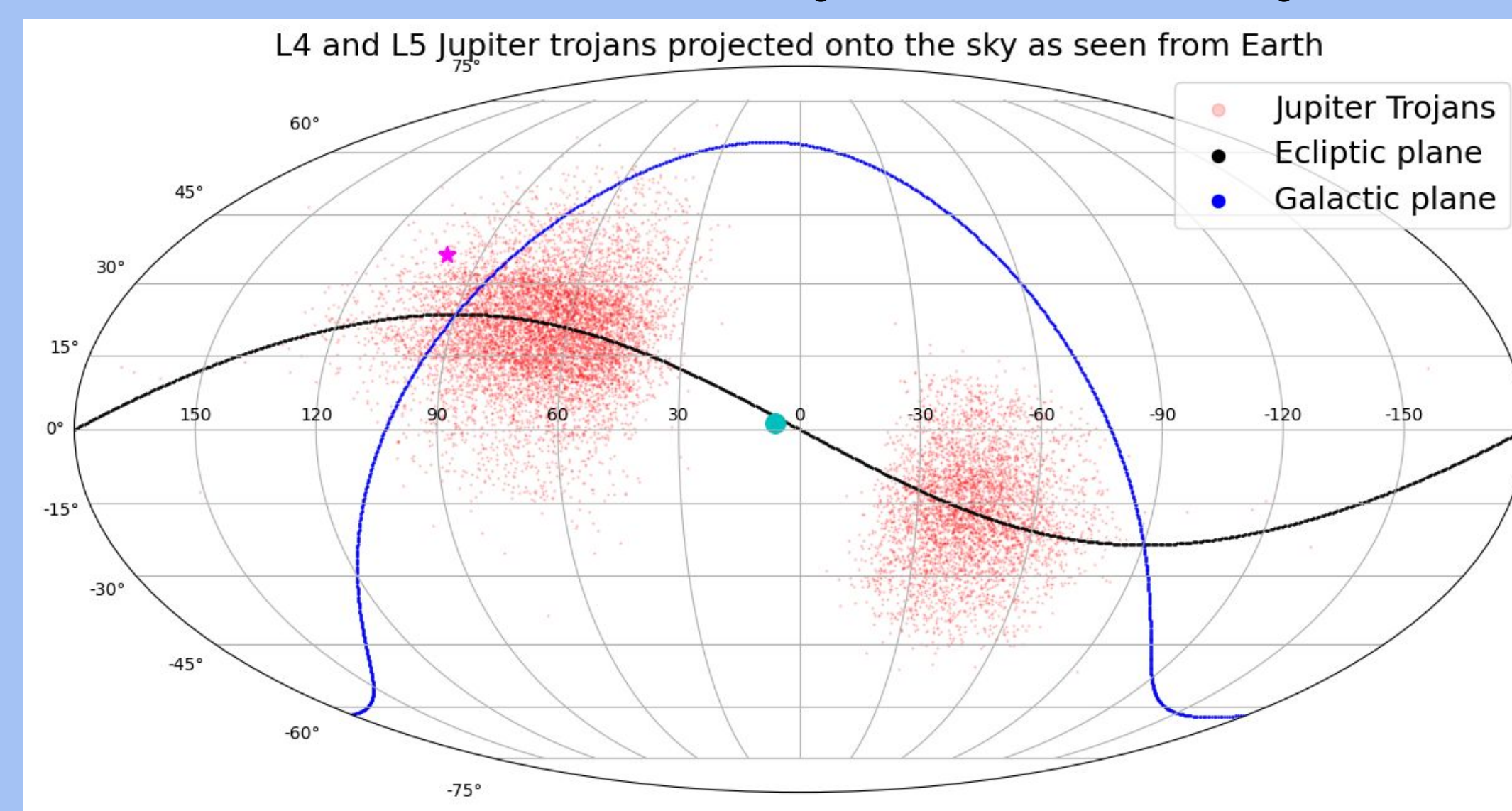


Fig 1: A mollweide projection of the sky with all known Jupiter trojans plotted for the night of February 3rd. The magenta star towards the top left indicates Polymele's position. The large cloud of trojans heading towards Jupiter by about 60° is the L4 trojan cloud and the trailing cloud is the L5 trojan cloud.

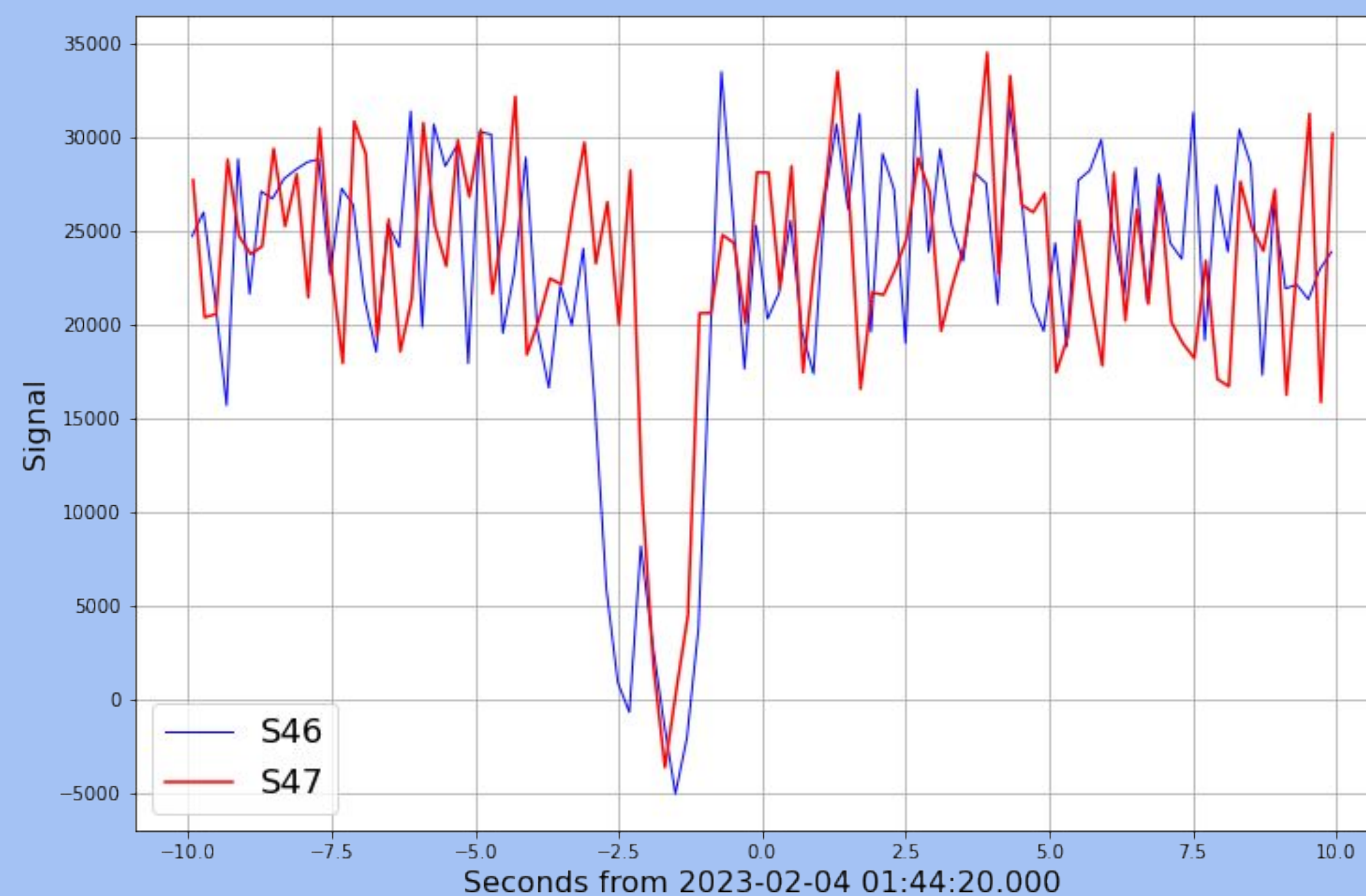


Fig 2: A plot of the light curves from tracks S46 and S47. The x-axis is centered around the predicted start time of the stellar occultation.

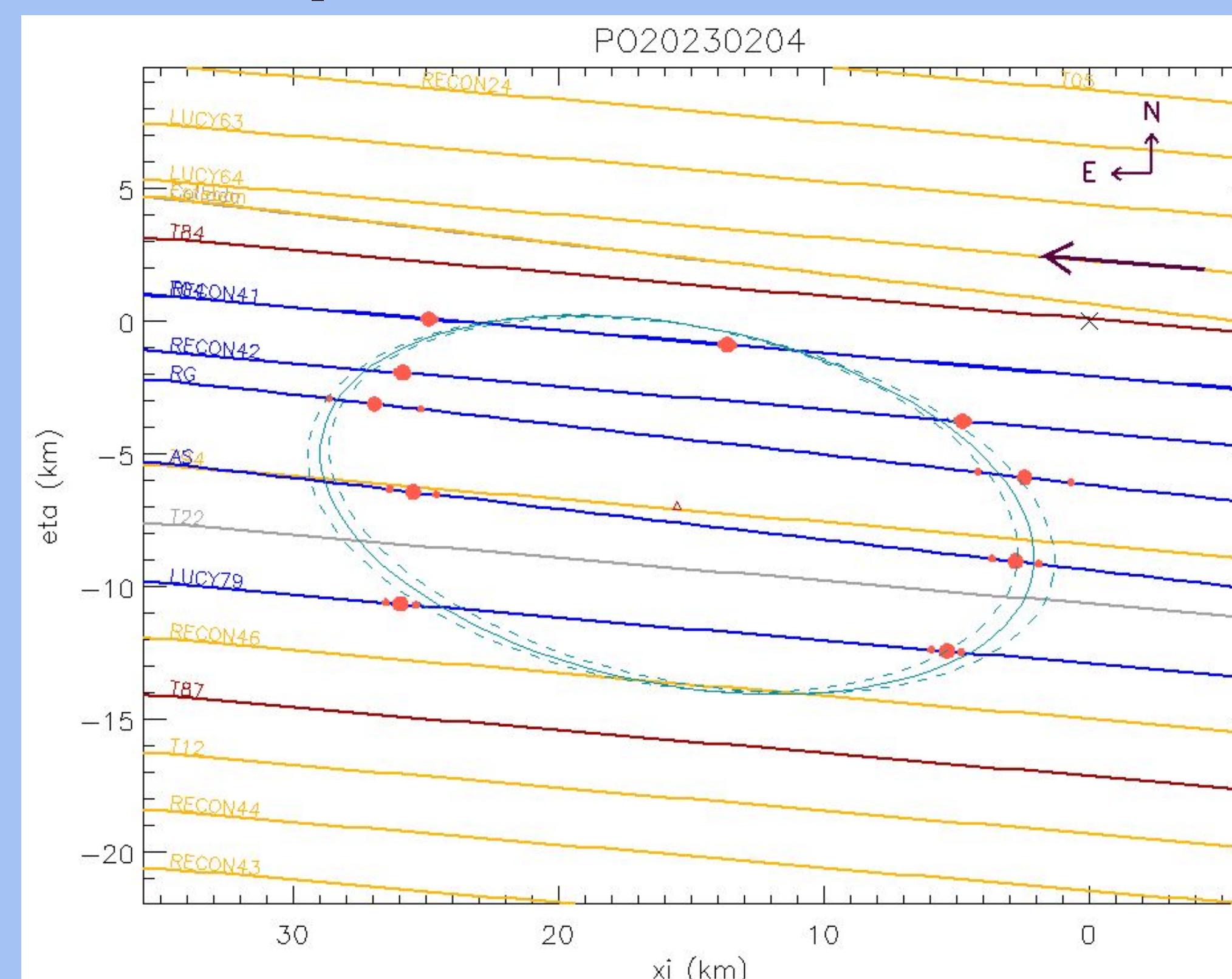


Fig 3: An approximate shape of Polymele drawn using the known start and end times of the occultation. Each blue line is a confirmed detection, and each red line is confirmed no detection and grey line is no usable data.

Preliminary Results

We successfully observed the occultation of Polymele, a small Jupiter trojan in the L4 cloud (Fig 2 and 4). Lucy will encounter Polymele in 2027. The occultation allowed for more exact dimensions of the asteroid so that Lucy's data will be far more precise (Fig 3). Additionally, we believe that we confirmed the sighting of Shaun. This data analysis and reduction is still ongoing.

Future Work

We are currently investigating the potential of an occultation for an L5 target that Lucy will be able to observe directly. We are working with several constraints on the timing of the occultation in relation to another of Lucy's planned events in 2033 and the fuel required to divert Lucy to directly image a L5 target. This investigation is ongoing and involves simulating the distributions of the L5 targets over the next 10 years.

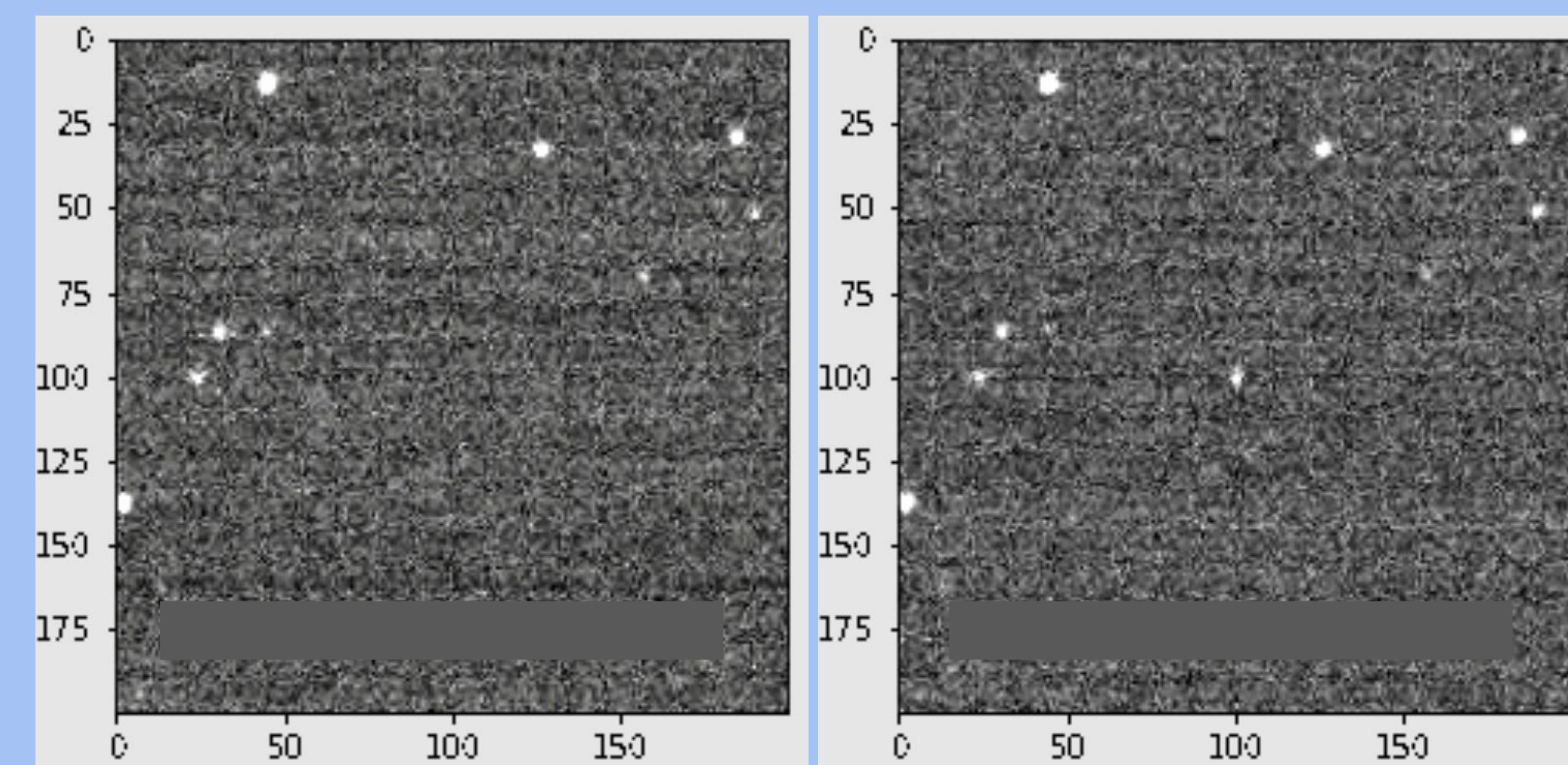


Fig 4: The star that Polymele passed in front of (centered in both images) briefly cuts out (left image) and comes back a few seconds later (right image). The length of time combined with the start and stop time of the stellar occultation is how we can gain information about the dimensions of asteroids.