EPSC Abstracts
Vol. 13, EPSC-DPS2019-1020-1, 2019
EPSC-DPS Joint Meeting 2019

Lightcurves, Shape Models, and H-G Parameters of Trojan and Hilda Binary Candidates

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Abstract

Knowing the formation location of Jovian Trojan (hereafter, Trojan) and Hilda asteroids has consequences on how the giant planets must have migrated early in solar system history. Bulk density, which can be inferred from binary asteroid systems, can be used to estimate formation location. However, few binaries are known for Trojans and none have yet been identified for Hildas, rendering hardly any observational evidence as to their dynamical origin. To identify more Trojan and Hilda binary systems for density and origin estimates, we are observing the rotational lightcurves of binary candidates in these two populations. As a consequence of our observing strategy, we are also occasionally able to fit H and G parameters to our data, giving further information about their surfaces. We present rotation and phase function results to date for dozens of our Trojan and Hilda targets, as well as results from our binary and singular-asteroid shape modeling efforts.

1. Introduction

One of the most influential and yet poorly constrained events in solar system history is giant planet migration. The objects that might have been most affected by this migration are Trojans, which lie in stable orbits at Jupiter's L4 and L5 Lagrange points, and Hildas, which are in 3:2 orbital resonance with Jupiter. Gentle planetary migration models necessitate in-situ formation of Trojans and Hildas [e.g., 1], while the Nice model of more rapid outward migration instead suggests an outer solar system origin [e.g., 2]. In other scenarios, Trojans and Hildas share a common origin [e.g., 3], while pebble accretion models predict Hildas to have formed at ~5-8 AU and Trojans at ~18 AU [4]. Asteroids that form farther from the Sun are able to retain ices, making them less dense, so constraining the density of Trojans and Hildas may provide information as to where they formed (Fig. 1). Only a few Trojan densities have been estimated, all from binary systems, and since no Hilda binaries are yet known, no Hilda densities have been measured [e.g., 5]. We are conducting the first large-sample search for Trojan and Hilda binaries with the aim of constructing a statistically meaningful density distribution for both populations. We will report on our results to date from our lightcurve campaign.

2. Observations

In [6], we identified dozens of binary asteroid candidates in the Trojan and Hilda populations via sparse photometry from the NEOWISE space mission [7]. Our strategy is to densely sample the rotational lightcurves for as many of these binary candidates as possible, determine a best-fit singular vs. binary shape model to assess or confirm binarity, then statistically compare our resultant Trojan and Hilda density distributions to those of other small body populations (Fig. 1).

Our follow-up campaign began in December 2014 and continues presently. Data have been obtained on NOAO's SOAR 4-m, McDonald Observatory's Struve 2.1-m, NOAO's WIYN 0.9-m, Steward's Kuiper 61" telescopes, and primarily the Las Cumbres Obervatory's global network of 0.4-, 1-, and 2-m telescopes. Data are taken in Sloan r', Bessel-R, and Harris-R filters, and there are typically ~200 data points per object.

As a consequence of many targets' datasets spanning weeks, we are sometimes also able to sample the lightcurve over a wide enough range of solar phase angles to constrain the solar phase function.

3. Preliminary Results

At the time of abstract submission, we have complete lightcurves of 14 Hildas and 6 Trojans, and H- and G-parameters for 6 Hildas and 1 Trojan. We measure rotation rates between ~7-210 hours, and nearly all targets have lightcurve amplitudes larger than 0.7 magnitudes (Fig. 2). The G slope parameters for Hildas appear to be relatively high for our targets. We will comment on our shape modeling efforts and the implications of our results.

4. Figures

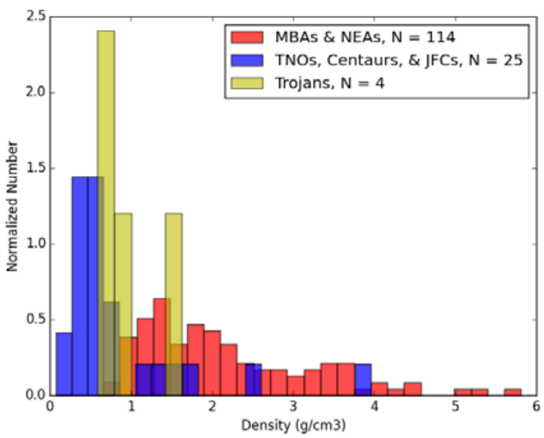

Figure 1: Normalized density distributions for inner Solar System (red), outer Solar System (blue), and Trojan asteroids (yellow; data from [8]). Red and blue distributions are different to 6.5σ.

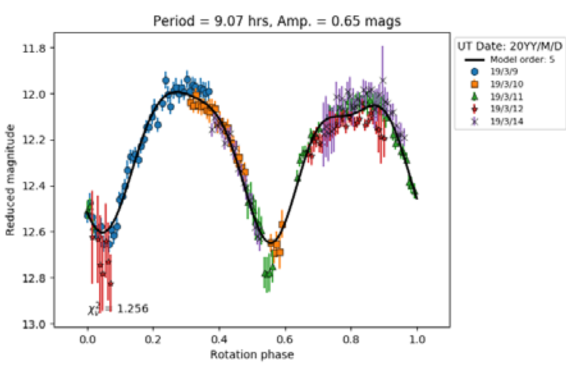

Figure 2: Phased lightcurve for one of our Trojan binary candidates, showing a peculiar dip at the 2nd maxima during one night, possibly indicative of a companion being eclipsed by a primary.

Acknowledgements

This material is based upon work supported by the National Aeronautics and Space Administration under Grant / Contract / Agreement No. NNX17AF20G issued through the SSO Planetary Astronomy Program. This paper makes use of data from the AAVSO Photometric All Sky Survey, whose funding has been provided by the Robert Martin Ayers Sciences Fund and from the NSF (AST-1412587). This publication makes use of data products from NEOWISE, which is a project of the Jet Propulsion Laboratory/California Institute of Technology, funded by the Planetary Science Division of the National Aeronautics and Space Administration.

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