THE COLLISIONAL EVOLUTION OF TROJAN ASTEROIDS—A POSSIBLE ORIGIN OF THE L4-L5 ASYMMETRY. David P. O'Brien[1] and Alessandro Morbidelli[2], [1]Planetary Science Institute, Tucson, AZ, USA (obrien@psi.edu), [2]Observatoire de la Côte d'Azur, Nice, France.

Abstract

The L4 and L5 Trojan swarms are asymmetric in terms of total number (see Fig. 1). For cataloged asteroids with H<12, L4 (leading) Trojans are roughly 25% more numerous than L5 (trailing) Trojans [1]. Recent estimates from the Sloan Digital Sky Survey suggest a leading/trailing ratio of 1.6 [2].

The recent model for Trojan capture by Morbidelli et al. [3] predicts equal efficiency of capture into the L4 and L5 regions, and would suggest that any differences between the two populations would be due to their subsequent evolution. Here we focus on differences that might result from collisional evolution.

A possible explanation for the asymmetry between the L4 and L5 swarms is that, given the small-number statistics involved with the capture of the largest Trojans, the L4 swarm originally began with several more large asteroids than the L5 swarm, and subsequent disruption of one or more of these asteroids generated large numbers of smaller asteroids. The current numbers of H<9 (diameter larger than ∼100 km) asteroids in the L4 and L5 swarms (19 and 15, respectively) are statistically comparable. The difference in total mass between the L4 and L5 swarms could be explained by the fragmentation of a single ∼350 km asteroid, or several ∼250 km asteroids (comparable in size to the largest Trojans currently present). While the collisional lifetimes of such bodies in the current Trojan populations are longer than the age of the Solar System, collisions would have been much more frequent in the early outer Solar System, as the massive primordial trans-Neptunian disk was being cleared out. Thus, it is possible that several large Trojan asteroids could have been broken up early in Solar System history.

A collisional origin of the L4/L5 asymmetry is supported by the fact that the L4 swarm has more asteroid families than the L5 swarm, and they are more robust [4, 5]. The intrinsic collisional probability for the L4 swarm is somewhat larger than for the L5 swarm, by about 20% [6, 7], which could be a contributing factor to the formation of families and may also be a result of it, as family members tend to have larger collision rates with one another compared to the background population. The enhancement of collision probability following a family formation event could be an important effect, as it could increase the likelihood of subsequent family formation, generating even more smaller asteroids.

Using a collisional evolution code (eg. [8]), modified to treat the stochastic effects of large impacts, we will explore and quantify this scenario. This has important implications for models of Trojan capture and dynamical evolution, as well as for models of the orbital migration of the outer planets (see, eg. [9]).

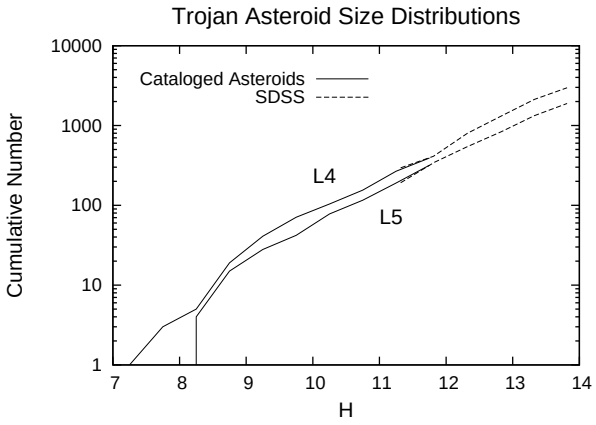

Figure 1: The size distributions of the L4 and L5 Trojan asteroids. Solid lines are cataloged data from [1], and dashed lines are from the Sloan Digital Sky Survey (SDSS) [2]. An absolute magnitude H of 8 corresponds to a diameter of ∼170 km, assuming an albedo of 0.04, and H of 12, which is approximately the completeness limit of the cataloged data, corresponds to a diameter of ∼25 km.

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