Jovian Trojans: Orbital structures versus the WISE data

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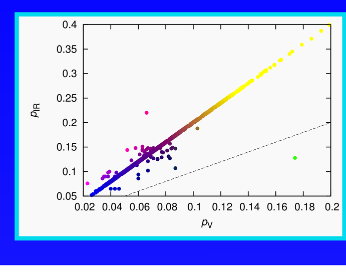

Abstract: In this work, we study the relation between orbital characteristics of Jovian Trojans and their albedos and diameters as measured by the WISE/NEOWISE mission (Grav et al. 2011, 2012).
In our previous work (Brož & Rozehnal 2011), we concluded that there is only one collisional family with parent body size larger than 100 km among Trojans, namely the Eurybates. This finding was based on the analysis of the observed size distributions, colour data from the Sloan Digital Sky Survey, and simulations of orbital evolution. The WISE albedos serve as an independent source of information which allows us to verify our previous results.
We also update our database of suitable resonant elements (i.e. the libration amplitude *D*, eccentricity *e*, inclination *I*) of Trojans and we look for new (to-be-discovered) clusters by the Hierarchical Clustering Method. Using the WISE diameters, we can construct more precise size-frequency distributions of Trojans in both the leading/trailing clouds which we compare to SFD of the cluster(s) mentioned above. We then prepare a collisional model (based on the Boulder code, Morbidelli et al. 2009).

1. Resonant elements computation

Resonant elements of 3773 Trojans in the leading (L4) and 1917 in the trailing (L5) cloud listed in the MPCORB database were computed with the SWIFT integrator (Levison et al. 1994) as described in Brož & Rozehnal (2011). This is approximately a twice larger sample than previously analysed (see Figure 1).
There are 4 (relatively) compact groups visible in L4 and 2 in L5, which we further analyse with the help of the HCM, SFDs and albedo data.

2. Hierarchical Clustering Method

We selected several largest bodies from each group, detected in the space of resonant elements, and we computed distances in this space to find a maximum cut-off velocity, at which the group is still compact (i.e. detached from the background, see Figure 2). To classify a group as a possible collisional family, we need an increasing number of bodies even for low values of v_{cutoff}. All 6 groups fulfill this criterion.

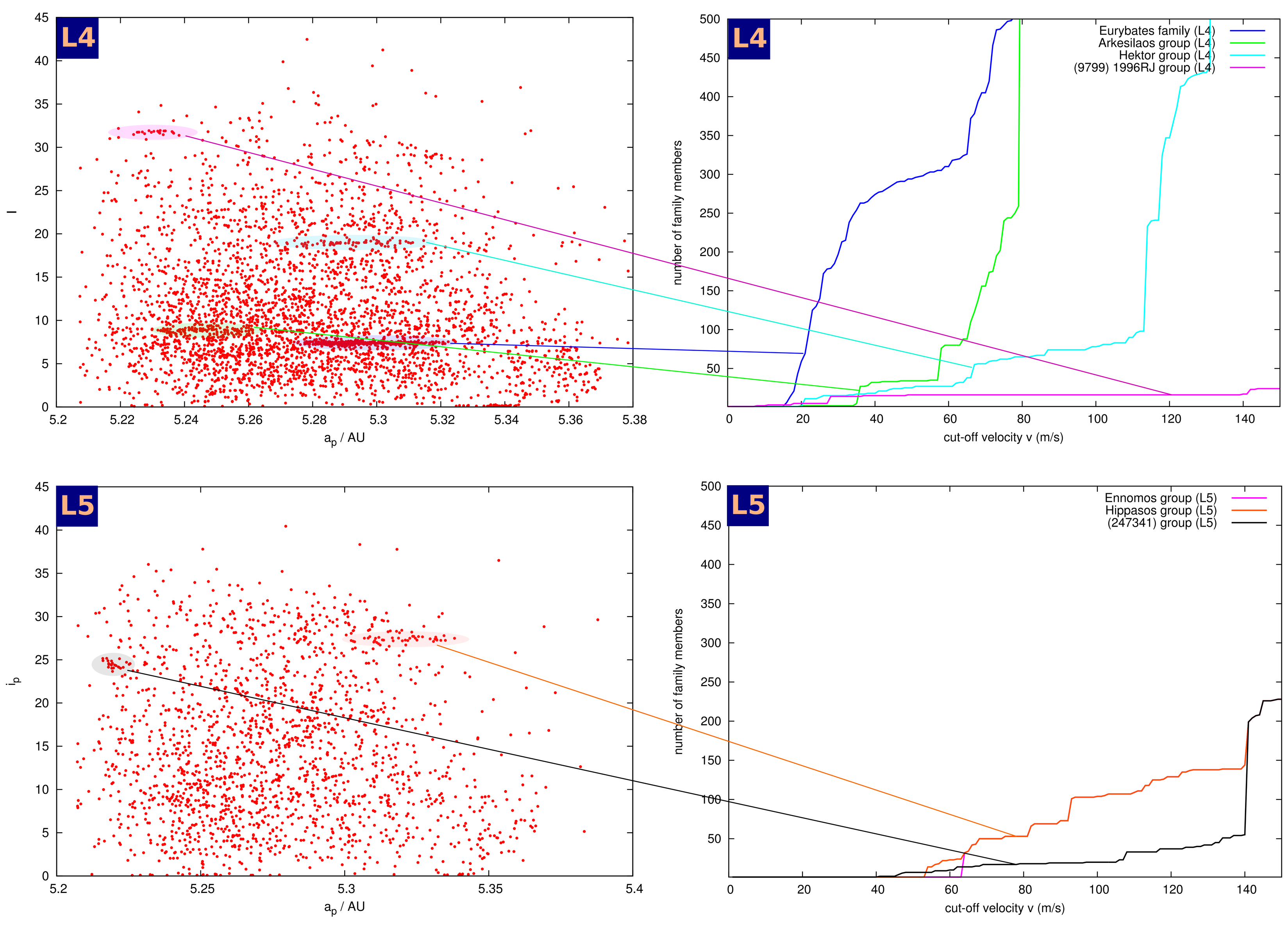

Figure 1: L4 (upper case) and L5 (lower case) Trojans in space of proper elements (*a*,*i*).

Figure 2: HCM: Dependence of number of possible families members in L4 (upper case) and L5 (lower case) on cut-off velocity.

3. Size-frequency Distributions

Diameters derived from WISE albedo measurements (Grav et al., 2011) were used to create size-frequency distributions for L4 and L5 Trojans. They were compared to the SFDs of compact groups (potential families) detected in the space of proper elements. The SFDs of L4 and L5 clouds seem to be very different; they also differ from the SFD we used in our previous work (with constant albedo, see Figure 3).

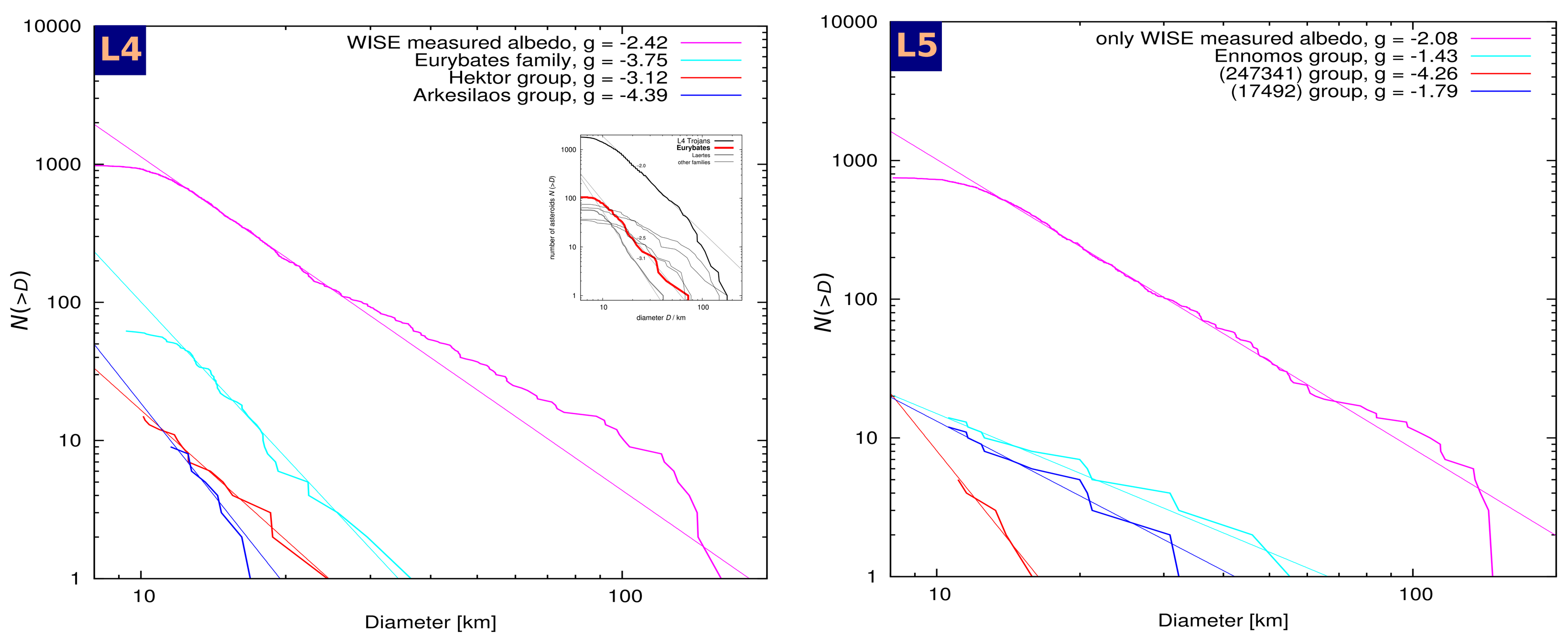

Figure 3: A comparison of the SFDs (slopes) of the compact groups in L4 (left) and L5 (right) to the overall SFD of Trojans, whose diameters were measured by WISE. Unfortunately, only the Eurybates family has a slope (-3.8) clearly different from that of the background (-2.4). The number of available albedos for other groups does not seem sufficient. The inset plot (on the left) shows previously derived slopes of L4 Trojans using p_V = const. assumption.

CONCLUSIONS I.

- The size-frequency distributions constructed from the WISE data are significantly different from those assuming p_V = const. (see Figure 3).
- We confirm that L4 and L5 differ in total number (as addressed by Nesvorný et al., 2013), the ratio for $D \geq 10$ km is $N_{L4}/N_{L5} = 1.6$.
- L4 and L5 populations differ also in the shape of SFDs for bodies with diameters in the range D = 50 to 100 km.
- We have detected no "new" catastrophic disruption of a body with diameter $D_{PB} > 100$ km - this is consistent with our previous work (Brož & Rozehnal, 2011).
- The group of bodies around (624) Hektor can be classified as possible "new" cratering event.
- We also found a small collisional family which may be associated with (247341).

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4. Splitting Trojans to low- and high-albedo poulations

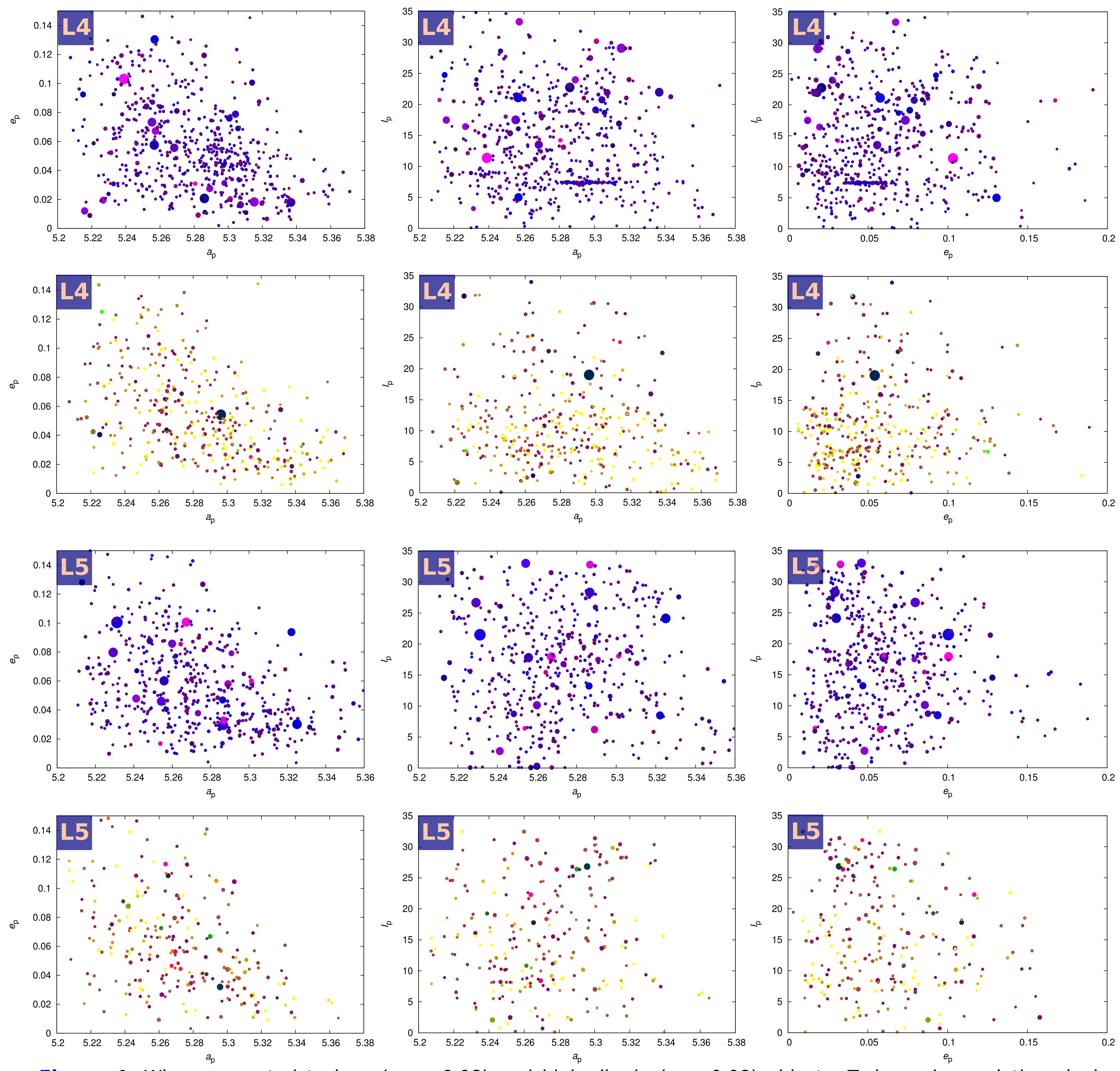

Figure 4: When separated to low- (p_V < 0.08) and high-albedo (p_V >0.08) objects, Trojan sub-populations look completely different in the space of proper elements. While large object dominate the low-albedo population (except (624) Hektor), the high-albedo population is composed of small bodies. Objects with highest albedos (yellow) seem to have limited inclinations, not exceeding 20 degrees. The colour palette is shown on top of the poster.

5. Differences between SFDs of low- and high-albedo populations

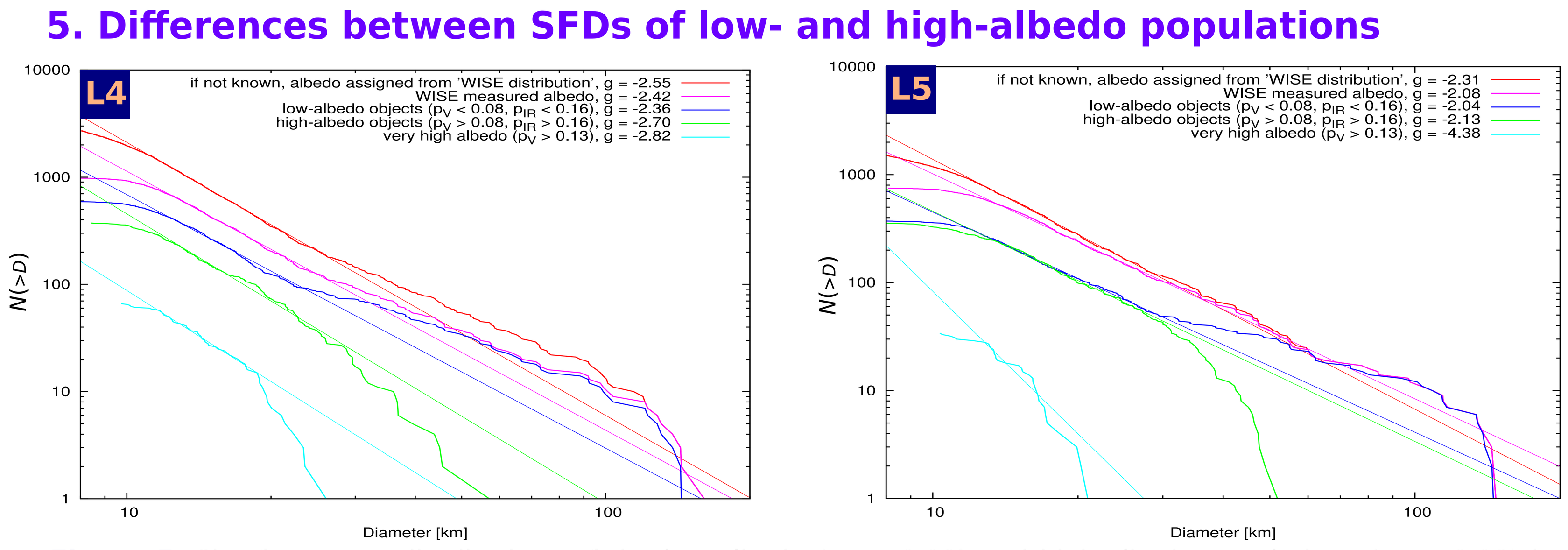

Figure 5: Size-frequency distributions of the low-albedo (p_V < 0.08) and high-albedo populations (p_V > 0.08) in case of L4 (left) and L5 Trojans (right). The "tails" (D < 20 km) of these distributions seem to be close to the collisional equilibrium (slope -2.5; Dohnanyi 1969).

6. Simulation of collisional evolution

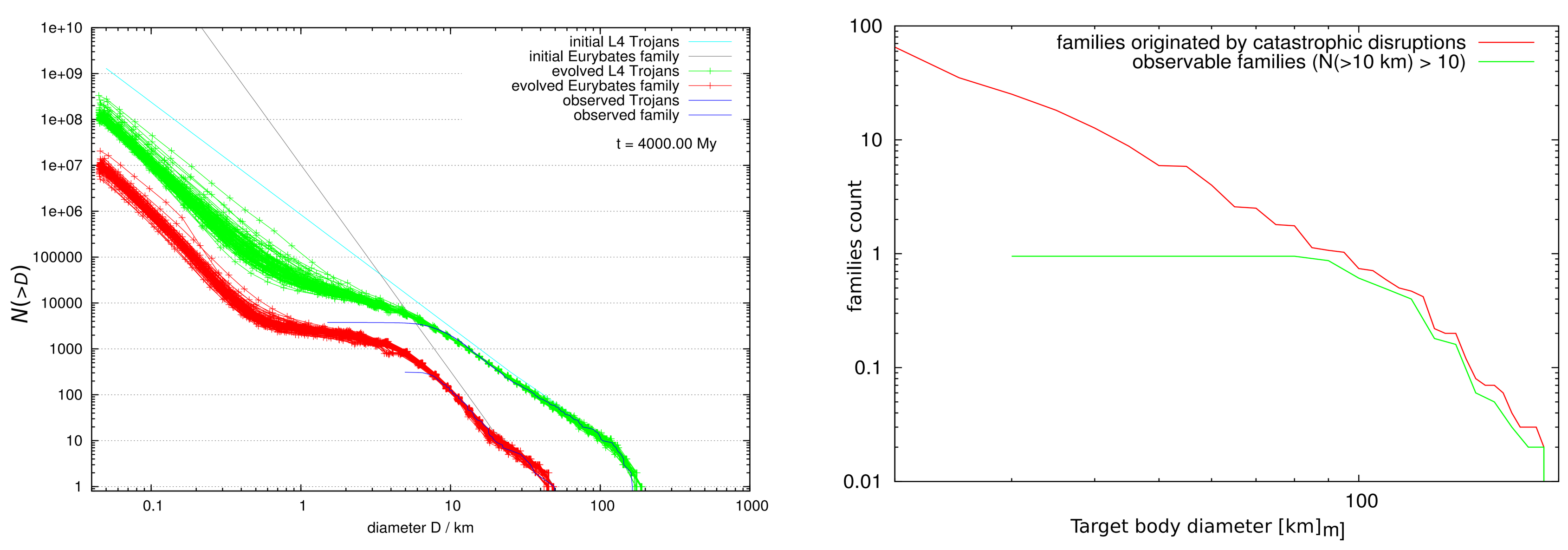

Figure 6: Left: A simulation of the collisional evolution of L4 Trojans with the Boulder code (Morbidelli et al., 2009). The evolution of bodies larger than D > 50 km is very slow, hence we can consider this part of the SFD as primordial.
Right: The dependence of the total number of catastrophic disruptions (average over 100 simulations) on the target diameter D_{PB}, and a subset of the families, which should be detected in contemporary observational data.

CONCLUSIONS II.

- When we divide Trojans to the low- (p_V < 0.08) and high-albedo (p_V > 0.08) populations, their SFDs are very different. That can be possibly explained by two different source regions: e.g. 1) the trans-neptunian region (Nesvorný et al., 2013), and 2) the main asteroid belt? (to be done).
- High-albedo Trojans (with p_V > 0.13) have markedly smaller range of inclinations (similar to high-albedo main-belt asteroids, which are restricted by the ν_6 secular resonance), but their SFD is much steeper than that of main-belt asteroids.
- Previously-discussed Ennomos family is not a high-albedo group. According to the WISE data, both the (4709) Ennomos and the nearby group have lower albedo (p_V = 0.09) than previously suggested (p_V = 0.15) by Fernández et al. (2003). It is still possible that the group is not associated with (4709) Ennomos.
- We are not yet able to discuss albedo homogenity of the 1996 RJ group due to the lack of data (only 4 members were measured by WISE).
- Collisional models show only little evolution above D > 50 km over last 3.85 Gyr (i.e. post-LHB phase).
- The expected & observable number of catastrophic disruptions (M_{LR}/M_{PB} < 0.5) with D_{PB} > 100 km is only 0.67 (an average over 100 simulations; we require $N_{fragments}(D>10$ km$) > 10$), which