Katie McGleam
TERPS Conference Abstract

Clues to the origin of Jupiter's Trojans: the libration amplitude distribution

Marzari, F, Tricarico, P, Scholl, H, 2003 Icarus 162, 453-459

This paper attempts to determine the processes which contributed to the trapping of Jupiter's Trojan asteroids Through numerical simulations, Marzari et al examine the effects of mutual collisions between planetesimals, rapid mass growth of Jupiter, and the dynamical instability of the Trojans in order to explain the current distribution of the Trojans' libration amplitudes Shoemaker et al (1989) theorized that collisions between planetesimals could kick the velocities of these objects and cause them to be trapped in orbit around the proto-Jupiter Fleming and Hamilton (2000) found a high Trojan capture rate in the time period when Jupiter is accreting the bulk of its mass through gas inflow Marzari et al simulate each of these situations alone, and then combine the two to see which best explains the current libration amplitude distribution

The first phase of Jupiter's growth is dominated by planetesimal accretion Marzari et al simulate collisions between the planetesimals surrounding the planet and find that just 1803 of their initial 5000 bodies are not scattered away after $2x10^4$ years Only about 9% of the survivors are trapped as Trojans, and only 12% of these have libration amplitudes smaller than 40 degrees In the observed distribution, the majority of Trojans have libration amplitudes less than 40 degrees

Next, the authors simulate the rapid gas inflow that occurs once the proto-Jupiter has reached a critical mass This simulation does not allow for collisions The fast mass growth is more efficient in capturing Trojans than the collisional method, but most would escape quickly Of the 5000 bodies that are integrated, about 37% are captured as Trojans, none of which have libration amplitudes less than 40 degrees The peak of this distribution (around 80 degrees) is again much higher than that of the observed distribution

Finally, the two trapping methods are combined, with the collisional effect turned on throughout both stages of mass growth Here, 7% of the initial bodies are trapped, and 19% of those captured have libration amplitudes less than 40 The two effects complement each other: when Trojans are captured early on by collisional means, the mass growth mechanism helps to stabilize them by reducing their libration amplitudes by about 40% (Fleming and Hamilton, 2000) This partially explains why, here, more of the Trojans have lower libration amplitudes

Still, however, the libration amplitude distribution of the combined simulation does not match the observed distribution An important mechanism that must be taken into account is the dynamical instability of the Trojan swarms, which causes the Trojans to slowly leak out over time (Levison et al, 1997) Once Marzari et al discard the Trojans which fall outside Levison et al 's stability zone, the libration amplitude distribution noticeably agrees with the observations

These results strongly suggest that the three effects must have worked together to produce the current distribution of Trojans However, Marzari et al have not considered the long-term collisional evolution of the system, which could significantly change the orbital properties Also, these mechanisms have been shown to capture and retain Trojans with similar libration amplitudes to those currently observed, but as of yet, they do not explain why Trojans have relatively high inclinations Nonetheless, this work provides important insights into the capture processes of Trojans