Outward transport and capture of main-belt asteroids by Jupiter and Saturn

A. Higuchi[1] and S. Ida[2]

[1]Tokyo Institute of Technology
[2]ELSI/Tokyo Institute of Technology

We have investigated the possibility of irregular satellites having their origin in the asteroid belt. The irregular satellites may not have been formed by accretion in a circumplanetary disk, as in the case of the regular satellites. The inclination distribution and large semimajor axes of the irregular satellites tell us that they must have formed elsewhere and later been captured into their current orbits around their host planets. Nesvorny et al. (2007, 2014) examined the possibility that irregular satellites were captured from the outer planetesimal disk during the early solar system instability when encounters between the outer planets occurred. In contrast, we calculate the orbital evolution of particles in the main asteroid belt due to gravitational scattering by Jupiter and Saturn for 20 Myrs or longer and investigate the possibility that the origin of the irregular satellites is in the main asteroid belt. The initial orbital elements of the particles are chose uniformly on the semimajor axis - Tisserand parameter plane. The range of Tisserand parameter with respect to Jupiter is around 3. During the calculation, we count the number of particles being the candidates for the irregular satellites of Jupiter and Saturn. We define that a particle staying within 3 Hill radius of the planet for time longer than the Kepler period of the host planet is a candidate for the irregular satellite. The orbits of the planets are given using the solution for the secular evolution obtained by a modified Fourier analysis in Laskar (1988). The values in Tables 6–13 in Laskar (1988) are used to calculate the orbits. The gravitational effects of the planets not included in the calculation are indirectly reflected in the orbital evolutions of Jupiter and Saturn. For example, the eccentricities and inclinations of Jupiter and Saturn oscillate with periods near 50 000 years. We compare the results with our previous study that we calculated with circular restricted 4-body problem and show how the secular changes of orbital elements of the planets affect on the capture process and the lifetime of the irregular satellites.

References: Nesvorný, D., Vokrouhlický, D., and Deienno, R. The Astrophysical Journal, Volume 784, Issue 1, article id. 22, 6 pp. 2014; Nesvorný, D., Vokrouhlický, D., and Morbidelli, A. The Astronomical Journal, Volume 133, Issue 5, pp. 1962–1976, 2007; Laskar, J., Astronomy and Astrophysics (ISSN 0004-6361), vol. 198, no. 1-2, p. 341–362, 1988.