ESTIMATION OF THE AGE OF TWO YOUNG PAIRS OF ASTEROIDS

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Introduction: Among the asteroids of the Main Belt, there are pairs of objects in close orbits whose members, as a rule, have a common origin, and the dynamic evolution of their orbits has common laws [1]. In [2], we identified candidates for young pairs by calculating the Kholshevnikov metrics and [3] and studying their dynamic evolution using nominal orbits. In this paper, we will estimate the age of two young pairs of asteroids (87887) 2000 SS286 – (415992) 2002 AT49 and (320025) 2007 DT76 – (489464) 2007 DP16 by studying their probabilistic evolution.

Method: To study probabilistic evolution for each asteroid, we generated 1000 trajectories with initial data from the confidence region, which corresponds to 1 million variants of the evolution of each pair. The simulation was carried out in the Orbit9 program (http://adams.dm.unipi.it/orbfit/), which is part of the OrbFit software package. The equations of motion of eight major planets, the dwarf planet Pluto and the asteroid, were integrated consistently, considering the influence of the Yarkovsky effect, the contraction of the Sun, and relativistic effects.

The Yarkovsky effect refers to non-gravitational perturbations and manifests itself as a secular drift of the semimajor axis d*a*/d*t*. The semimajor axis drift caused by the Yarkovsky effect had a significant impact on forming the main asteroid belt. To estimate the drift velocity of the semimajor axis, we used the approach proposed in [4]. This approach is based on the normalization of the physical and dynamic parameters of the asteroid (101955) Bennu. In contrast to the traditional approach, considering the Yarkovsky effect, we obtained age estimates for several fixed values of the semimajor axis drift velocities corresponding to different positions of the asteroid's rotation axis tilt to the orbital plane.

We analyzed the conditions of low-speed encounters: $\Delta r < 10\ R_H$, $\Delta v < 4\ V_{esc}$, where R_H is the radius of the Hill sphere of the more massive asteroid in the pair, V_{esc} is the escape velocity relative to the more massive asteroid, Δr is the relative distance between asteroids, and Δv is the relative velocity of the asteroids.

Results: The age estimate of the pair (87887) 2000 SS286 - (415992) 2002 AT49 ranges from 7.58 ± 0.035 to 8.8 ± 0.043 kyr depending on the drift rate of the semimajor axes. The minimum age estimate corresponds to the variant in which for the first asteroid (87887) 2000 SS286 the drift velocity of the semimajor axis of the asteroid is $\mathrm{d}a/\mathrm{d}t = -1.1 \cdot 10^{-4}$ au/Myr, and for the second asteroid (415992) 2002 AT49 it is $1.9 \cdot 10^{-4}$ au/Myr. The maximum estimate corresponds to the drift velocities of $1.1 \cdot 10^{-4}$ au/Myr and $-1.9 \cdot 10^{-4}$ au/Myr, respectively. Our estimate is close to the estimate of 7.4 ± 0.3 kyr obtained in [5].

For the pair (320025) 2007 DT76 – (489464) 2007 DP16, the age estimate ranges from 15.4 ± 0.96 to 29.5 ± 0.04 kyr. The age of this pair significantly depends on the value of the semimajor axis drift. In [5], the age is estimated for this pair – more than 10 kyr.

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