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Evolution of the Edgeworth-Kuiper Belt

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Abstract. Due to gravitational interactions with large trans-neptunian objects (TNOs) several percent of TNOs can change their semimajor axes by more that 1 AU during last 4 Gyr. Now about 30000 1-km former TNOs can be Jupiter crossers and about 20% of Earth-crossing objects can be former TNOs which now move in Jupiter-crossing orbits.

The total mass of planetesimals that entered the trans–neptunian region from the feeding zone of the giant planets during their accumulation could exceed tens of Earth masses (Ipatov 1987, 1993). These planetesimals could increase eccentricities of 'local' trans–neptunian objects (TNOs) and swept most of them. A small portion of such planetesimals could be left beyond Neptune's orbit in highly eccentric orbits. Probably, most of large (with diameters $d \geq 100$ km) local TNOs were formed by the compression of rarefied condensations but not by the accumulation of smaller planetesimals.

The probability of a collision of a TNO with $d \geq 100$ km at 40 AU with some other such TNOs during last 4 Gyr is about 0.5%. Most of TNOs with such sizes survived during this age. The probability of destruction of a TNO with a semimajor axis $a < 50$ AU by other TNOs with such a can be less than that by "scattered" objects moving in highly eccentric objects with $a > 50$ AU. The role of mutual gravitational influence of TNOs in variation of their orbital elements is greater than the role of their collisions. At the present mass of the Edgeworth-Kuiper Belt (EKB) due to the mutual gravitational influence of TNOs during the last 4 Gyr, the variation in a of an object located in the middle of the EKB usually does not exceed 0.1 AU, a could decrease by more than 1 AU for many objects at the inner part of the belt, and several percents of TNOs could take part in such very close encounters when a changed by several AU (Ipatov 1998). Even small variations in orbital elements of TNOs caused by their mutual gravitational influence and collisions can cause large variations in orbital elements due to the gravitational influence of planets (Ipatov and Henrard 2000).

Due to the gravitational influence of planets and mutual close encounters, some TNOs can migrate inside the Solar System. Ipatov and Hahn (1999) showed that the mean time interval, during which an object crosses Jupiter's orbit during its lifetime, is about 0.2 Myr, the portion of Jupiter-crossers that reach the orbit of the Earth during their lifetimes is equal to 0.2, and the mean time, during which a Jupiter-crosser crosses also the orbit of the Earth, is about 5000 yr. Basing on the above data and some results obtained by other scientists and considering the number of 1-km TNOs with $a < 50$ AU to be equal to 10^{10}, Ipatov (1999) obtained that the number of the present Jupiter-crossers with

$d > 1$ km, which came from the EKB, equals to 30000 and about 170 of them cross both the orbits of Earth and Jupiter (i.e., these former TNOs make up about 20% of all Earth-crossers with $d > 1$ km). The portion of such objects colliding with the Earth is smaller than their portion among Earth-crossers, because the characteristic time elapsed up to a collision with the Earth for a Jupiter-crosser is larger by a factor of several than that for an Apollo object (the latter is on average about 100 Myr). The number of former Jupiter-crossers that move inside Jupiter's orbit in Encke-type orbits can be of the same order (or even more) than the number of objects that cross both the orbits of Jupiter and Earth. Probably, the number of scattered TNOs migrating inside the Solar System can be of the same order as that of typical EKB objects considered above.

References

Ipatov, S.I. 1987, Earth, Moon, & Planets, 39, 101

Ipatov, S.I. 1993, Sol. Syst. Res., 27, 65

Ipatov, S.I. 1998, in "Planetary systems: the long view", ed. L. M. Celnikier and Tran Thanh Van (Editions Frontières), 157

Ipatov, S.I. 1999, Celest. Mech. & Dyn. Astron., 73, 107

Ipatov, S.I. and Hahn, G.J. 1999, Sol. Syst. Res., 33, 553

Ipatov, S.I. and Henrard, J. 2000, Sol. Syst. Res., 34, 61