MIGRATION OF ASTEROIDAL DUST.

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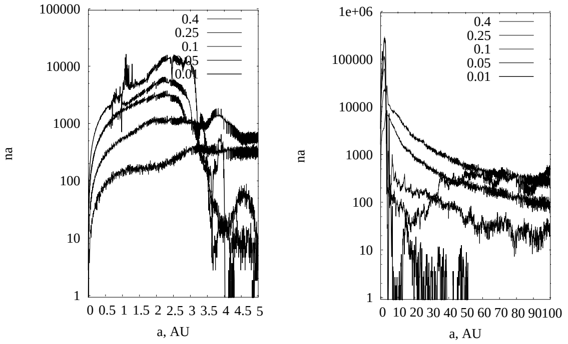

Figure 1: Dependence of the number of dust particles on semi-major axis

Table 1: Values of T (in Kyr), P_r, and P_{Sun} (Venus=V, Earth=E, Venus=V)

		V	V	E	E	M	M
β	P_{Sun}	P_r	T	P_r	T	P_r	T
0.01	1.000	1534	19.2	1746	44.2	127	99.9
0.05	0.996	195	4.0	190	8.1	36.7	20.5
0.1	0.990	141	2.4	132	4.8	16.4	12.0
$0.1*$		366	2.4	279	4.8	20.9	12.0
0.25	0.618	79.2	1.4	63.8	2.9	5.60	5.9
0.4	0.316	12.4	1.5	8.0	2.5	0.72	8.8

Using the Bulirsh–Stoer method of integration, we investigated the migration of dust particles under the gravitational influence of all planets, radiation pressure, Poynting–Robertson drag and solar wind drag for β equal to 0.01, 0.05, 0.1, 0.25, and 0.4. For silicate particles such values of β correspond to diameters equal to about 40, 9, 4, 2, and 1 microns, respectively [1]. The relative error per integration step was taken to be less than 10^{-8}. Initial orbits of the particles were close to the orbits of the first numbered main-belt asteroids. For each $\beta \geq 0.05$ we considered N=500 particles (N=250 for β=0.01). In each run we took N=250, because for $N \geq 500$ the computer time per calculation for one particle was greater by a factor of several than that for N=250. In our runs planets were considered as material points, but, basing on orbital elements obtained with a step 20 yr, similar to [2] we calculated the mean probability P=P_Σ/N (P_Σ is the probability for all N considered particles) of a collision of a particle with a planet and the mean time T=T_Σ/N during which perihelion distance q of a particle was less than a semi-major axis of the planet. Below P_{Sun} is ratio of the number of particles collided with the Sun to the total number of considered particles. The values of P_r=$10^6 P$ and T are shown in Table 1 for N=250 (for β=0.1 we present two runs with different 250 particles), and P_{Sun} was obtained for all considered particles.

The less are the particles (i.e., the greater is β), the smaller is P_{Sun} (i.e., the greater is the portion of the particles which are blown away by solar wind) and the less is the probability of collisions of particles with the terrestrial planets. The total time of the evolution until the last particle collided with the Sun or reached 2000 AU from the Sun was less than 0.8 Myr in all runs. Several plots concerning the distribution of migrating particles in their orbital elements and the distribution of particles with their distance R from the Sun and their height h above the initial plane of the Earth's orbit are presented in Figs. 1-3. The number of considered bins in a is 1000 for Fig. 1. For other figures the number of bins in a or R equals to 100, and the number of bins in e or h usually is a little less than 100. We obtained that the number n_a of migrating particles with semi-major axis a in the interval with a fixed width is greater for smaller β at semi-major axes a<3 AU. In Fig. 1 the values of n_a at a=2 AU are greater for smaller β and those at a=20 AU are smaller for smaller β. For $\beta \leq$ 0.1 the values of n_a are much smaller at a>3.5 AU than at 1<a<3 AU, they are usually maximum at $a \approx$2.3 AU (for β=0.01 the local maxima of n_a at 1.09 and 1.11 AU are almost the same as the main maximum). For all considered β, n_a considerably decreases with a decrease of a at a<1 AU and usually decreases with an increase of a at a>5 AU (Fig. 1). Relatively large values of n_a at a>40 AU for β=0.05 are due to only one particle. For a>5 AU the values of n_a are greater by a factor of several at β=0.25 than at β=0.4.

The greater is β, the greater are mean eccentricities (Fig. 2). At $\beta = 0.01$ some particles got into the resonance 1:1 with Jupiter. For a>10 AU perihelia were usually near Jupiter's orbit (for β=0.05 and β=0.25 also near Saturn's orbit). In almost all cases, inclinations i<50^o; at a>10 AU maximum i was smaller for smaller β. Usually there are no particles with h/R>0.7 at R<10 AU, with h/R>0.25 at R>20 AU for $\beta \leq$0.1, and with h/R>0.5 at R>50 AU for $\beta \geq$0.25. For $\beta \geq$0.4 at R<1000 AU almost all region with h/R<0.3 was not empty (Fig. 3).

The total time spent by 250 particles in inner-Earth, Aten, Apollo and Amor orbits was 5.6, 1.4, 4.5, and 7.5 Myr at β=0.01, and 0.09, 0.08, 0.48, and 0.76 My at β=0.4, respectively.

This work was supported by NRC (0158730), NASA (NAG5-10776), INTAS (00-240), and RFBR (01-02-17540).

References: [1] Moro-Martin A. and Malhotra R. (2002) *Astron. J.* 124, 2305-2321. [2] Ipatov S. I. and Mather J. C. (2002) *Advances in Space Research*, submitted (http://arXiv.-org/format/astro-ph/0212177).

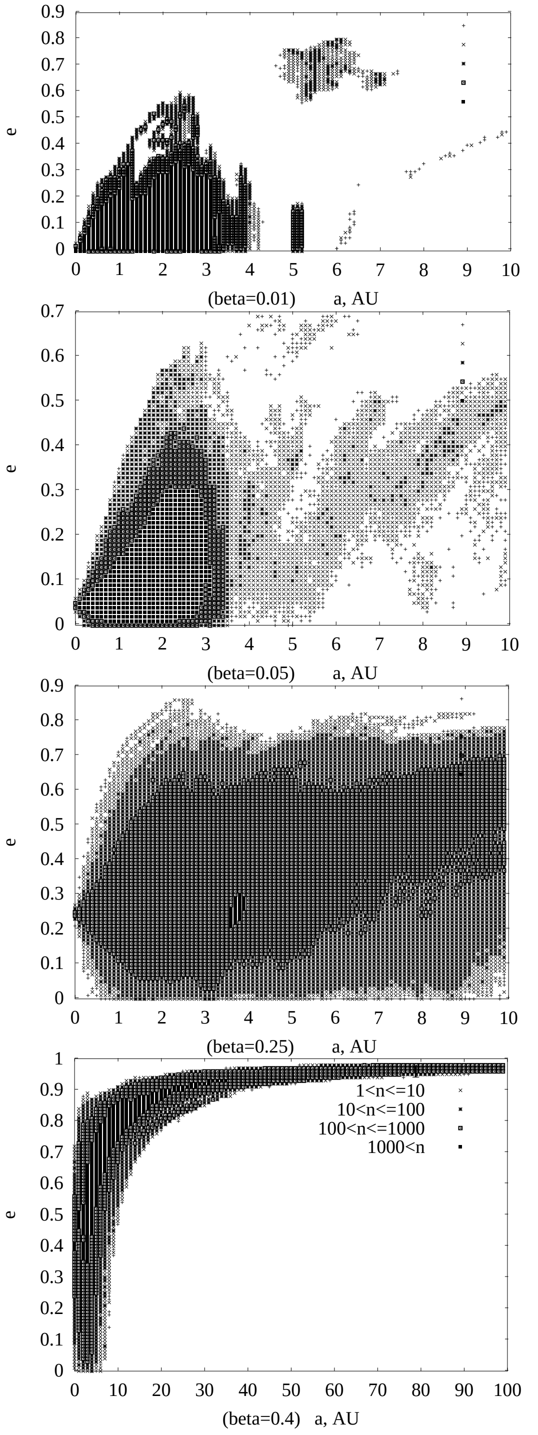

Figure 2: Distribution of dust particles with semi-major axis and eccentricity (designations of the number of particles in one bin are the same for Figs. 2 and 3)

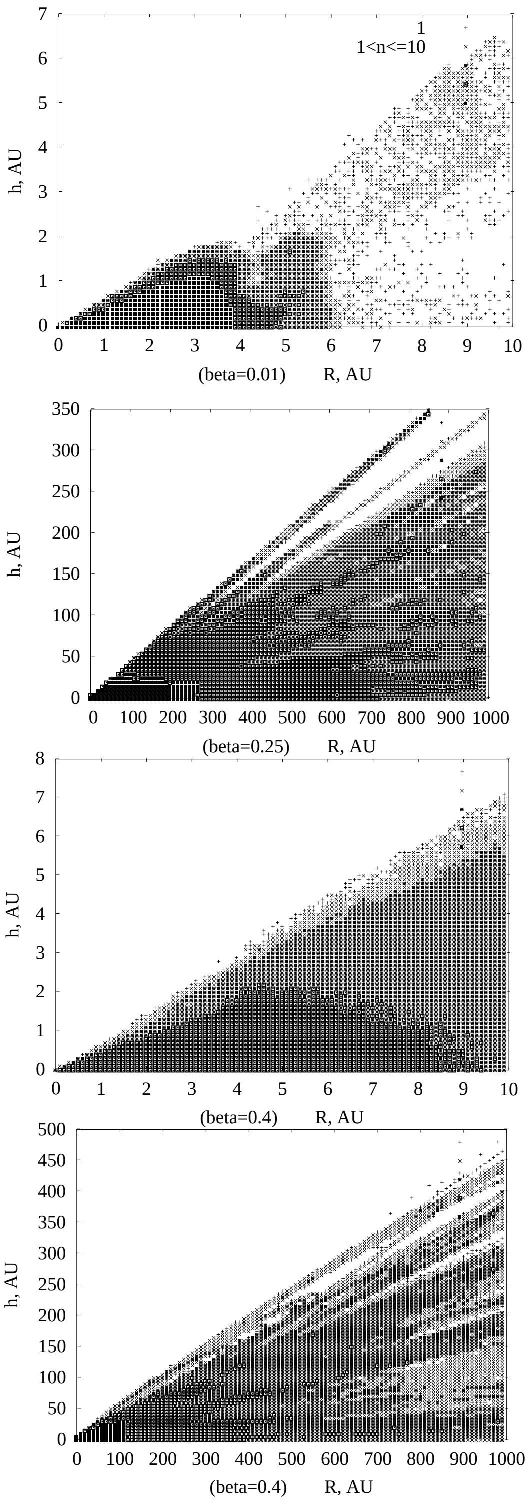

Figure 3: Distribution of dust particles with distance R from the Sun and height h above the initial plane of the Earth's orbit