

TEMPORARY TRAPPING OF DUST PARTICLES INTO ORBITAL RESONANCES WITH THE EARTH

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We have studied the orbital evolution of interplanetary dust particles beyond the Earth's orbit under the action of Poynting-Robertson (PR) drag and gravitational perturbations of the Earth and Jupiter. The particle orbits were integrated by directly introducing in the equation of motion the position vectors of the Earth and Jupiter as obtained from the Richardson-Walker numerical simulation of the motion of the full planetary system (1). This allowed us to take account of the "real" evolution of the Earth's and Jupiter's orbits (under all the planetary perturbations) and, therefore, of their influence on the motion of the dust particles in Earth's neighborhood. In this respect, the present study differs and extends previous work on the orbital evolution of dust particles under PR drag with only a single or few perturbing planets (2, 3, 4) whose orbits were directly integrated.

As pointed out by Jackson and Zook (2, 3) and by Weidenschilling and Jackson (4), the combination of PR drag and gravitational perturbations by a planet can lead to interesting consequences, among them the apparently most noticeable is the temporary trapping of dust particles into a variety of orbital resonances with the planet. This resonant trapping was investigated in (4) in the context of the circular restricted three-body problem with analytic methods complemented by numerical integrations.

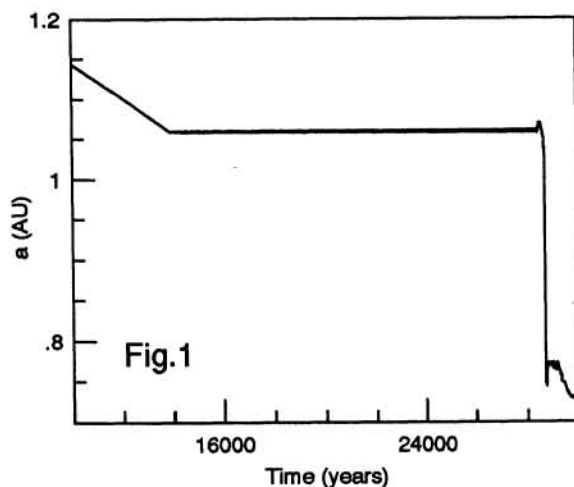
Since trapping in resonances and escape from them are phenomena related to the mutual geometrical configuration of the particle's and the planet's orbit (the Earth, in our case), orbital variations induced by planetary perturbations and, in particular, the precession of the particle's and the Earth's perihelion and their nodes can play an important role in the real picture of the phenomena (5, 6). This is expected also on the basis of the simple argument that the length of trapping in resonances found with the simple models of (2, 3, 4) are comparable to the typical oscillation periods of the eccentricities, inclinations, perihelion arguments and node's longitudes of Venus, the Earth, Jupiter, and Saturn (v. Figs. 6-10 in (1)).

Our numerical study based on the use of the data of the Richardson-Walker numerical integration, for the Earth and Jupiter orbital evolution, shows how the dynamics of trapping in resonances is controlled by the distance between the mutual nodal points of the particle and the Earth (for a not too small mutual inclination of their orbits). In general, closest approach of the two orbits occurs in the vicinity of one pair of the mutual nodes (7) and deep close encounters, which cause the escape of the particle from the resonance, can occur for short spans of time around the epochs of the node crossings (8). The eccentricity increases during the trapping, becoming so large that the particle cannot avoid such close encounters.

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Figures 1-3 show some results of our study for particles started at semimajor axis $a = 1.3$ AU, with zero initial eccentricity and inclination and the α parameter for the PR drag equal to half the value chosen in (9). The dust particle is trapped for 14,500 years in the 8/9 resonance with the Earth. Escape from it occurs in correspondence to a deep close approach (Fig. 3).

1. Richardson, D.L. and C.F. Walker, (1989) *J. Astronaut Sci.* **37**, 159; 2. Jackson, A.A. and H.A. Zook (1988) *Lun. Plan. Sci.* **19**, 539; 3. Jackson, A.A. and H.A. Zook (1989) *Nature* **337**, 629; 4. Weidenschilling, S.J. and A.A. Jackson (1990) "Orbital Resonances and Poynting-Robertson Drag," preprint; 5. Gustafson, B.A.S. and N.Y. Misconi (1987) *Icarus* **66**, 280; 6. Burns, J.A. (1987), in *The Evolution of the Small Bodies of the Solar System* (North-Holland), 252; 7. Greenberg, R. (1982) *Astron. J.* **87**, 184; 8. Milani, A., M. Carpino, G. Hahn, and A.M. Nobili (1989) *Icarus*, **78**, 212; 9. Gonczi, R., Ch. Froeschle, and Cl. Froeschle (1982) *Icarus* **51**, 633.



Orbital evolution of a particle initiated at $a = 1.3$ AU, with zero initial eccentricity and inclination and the PR-drag α parameter set at 10^{-5} AU²/year. Figs. 1, 2 and 3 show the variation of the semimajor axis, eccentricity and mutual ascending (solid line) and descending (dotted line) node distance, respectively.

