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DUST GRAIN RESONANT CAPTURE: A STATISTICAL STUDY

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A statistical approach, based on a large number of simultaneous numerical integrations, is adopted to study the capture in external mean motion resonances with the Earth of micron size dust grains perturbed by solar radiation and wind forces. We explore the dependence of the resonant capture phenomenon on the initial eccentricity e_0 and perihelion argument ω_0 of the dust particle orbit. The intensity of both the resonant and dissipative (Poynting–Robertson and wind drag) perturbations strongly depends on the eccentricity of the particle [1] while the perihelion argument determines, for low inclination, the mutual geometrical configuration of the particle's orbit with respect to the Earth's orbit. We present results for three j:j+1 commensurabilities (2:3, 4:5 and 6:7) and also for particle sizes s=15, 30 μm. This study extends our previous work on the long term orbital evolution of single dust particles trapped into resonances with the Earth [2].

The orbits of about 1000 dust particles are simultaneously integrated with the Everhart method [3] taking into account the gravitational attraction of the five major influencing planets, Venus, Earth, Mars, Jupiter and Saturn (a seven–body problem). The initial positions of the planets are derived from the ephemerides JPL DE200 at the epoch 1993.0. The orbital evolution of all the dust particles initiates at the same semimajor axis a_0, whose value has been chosen close to the resonant value a_R appropriately modified by radiation pressure ($\beta = 0.122/s$, s in μm [4]).

In Fig. 1 we show the trapping regions for the 2:3 resonance (a_R=1.3086 AU) in the (e_0, $\omega_0 - \omega_{0E}$) plane, with ω_{0E} perihelion argument of the Earth's orbit at 1993.0. The initial inclinations of the dust particles, referred to the ecliptic plane, are set to 10°, the longitudes of node to 0° and the mean anomalies to 90°. The filled circles represent particles trapped into resonance while the dots represent particles passing through the resonance without being trapped. We have verified, using a finer sampling interval both in e_0 and ω_0, that these regions are stable against small variations in the two orbital parameters. The maximum probability of capture occurs for eccentricities close to $e_0 \simeq 0.23$ for which the dust grain's and planet's orbits become crossing. This correlation between the location of trapping regions and the particle's eccentricity at almost tangent orbits is confirmed for the 4:5 and 6:7 commensurabilities (see Figs. 2 and 3, respectively). The trapping regions for the latter resonances are shifted downward with respect to Fig. 1 and are centered around the values $e_0 \simeq 0.13$ and $e_0 \simeq 0.95$, respectively, for which the Earth's and particle's orbit begin to cross. As a consequence low eccentricity dust particles are captured more frequently in high–j resonances.

Results for a 15 μm dust–particle size at the 4:5 commensurability are shown in Fig. 4. In this case the capture occurs only in small isolated regions. The marked difference with respect to the cases of Figs. 1–3, can be regarded as a consequence of the increased decay rate for smaller particles.

REFERENCES: [1] Sicardy B., Beaugè C., Ferraz-Mello S., Lazzaro D., Roques F., *Cel. Mech.*, in press; [2] Marzari F., Weidenschilling S.J., Fabris M. , Vanzani V. (1991) ***LPSC XXII***, 861; [3] E. Everhart, in ***Dynamics of Comets: Their Origin and Evolution*** (Reidel, Dordrecth, 1985), p. 185; [4] See: Mukai T., Schwehm G. (1982), ***Astron. Astroph. 107***, 97;

Figs. 1–3. Trapping regions in the (e_0, $\omega_0 - \omega_{0E}$) plane for the 2:3, 4:5 and 6:7 resonances, respectively, for a 30 μm particle size. **Fig. 4**. For a particle size reduced to 15 μm trapping occurs only in small isolated regions (4:5 resonance).

Fig. 1

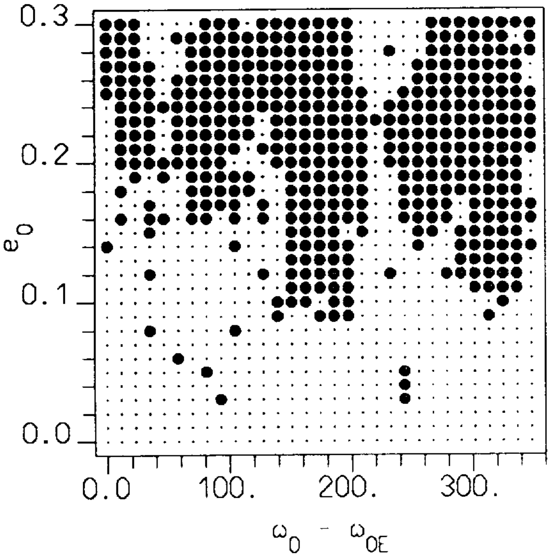

Fig. 2

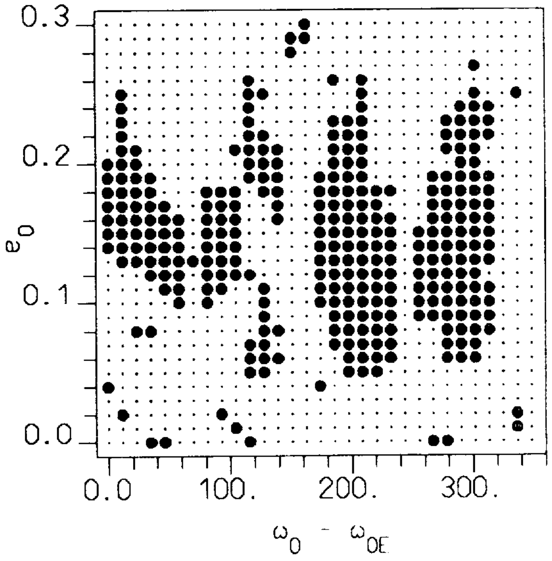

Fig. 3

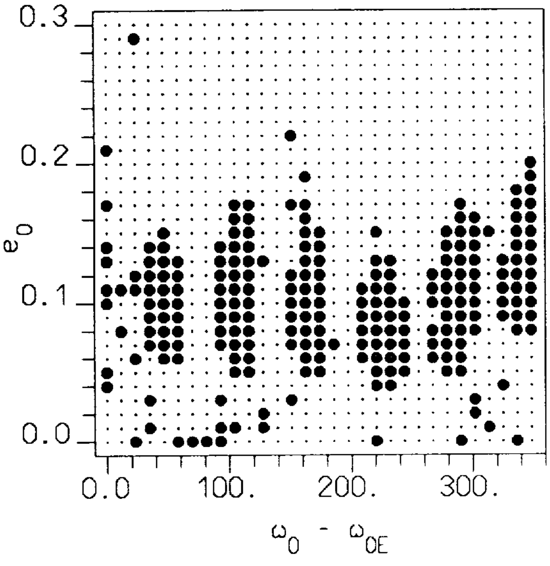

Fig. 4