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## ORBITAL EVOLUTION OF DUST FROM COMET SCHWASSMANN-WACHMANN 1: A CASE OF ONE-TO-ONE RESONANCE TRAPPING.

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In a recent study [1] we have modeled the orbital evolution of dust particles released from comets and asteroids in the solar system. The source bodies were either asteroids inside Jupiter's orbit or comets from the Jupiter family of comets. However there are other dust producing parent bodies in the solar system of interest, one of these is comet P/Schwassman-Wachmann 1. Since comet Schwassman-Wachmann 1 has an orbit outside of Jupiter's orbit, is an active dust producer and has low eccentricity, dust particle evolution from it is of interest. We report on a particular 2 micron radius particle that captured into a 1 to 1 mean motion resonance orbit with Saturn.

Our method was to numerically integrate the equations of motion of dust particles evolving from comet Schwassman-Wachmann 1. The particles were released at perihelion and are modeled as ideal black bodies of density 1 gm/cc. The forces are those of the Sun and eight planets, radiation pressure and Poynting-Robertson (PR) and solar wind drag. The planets are all moved in their correct n-body orbits. Dust evolving from comets follow complicated orbital evolution histories in the solar system. Radiation forces can bring dust particles into various gravitational configurations with respect to the planets that include scattering, and capture into exterior and interior mean motion resonances. We discuss the motion of a particular 2 micron particle.

Comet Schwassman-Wachmann 1's orbital elements [2] are semimajor axis ,  $a = 6.041$ , eccentricity,  $e = .0445$  and inclination  $i = 9.4$  degrees. Upon release a 2 micron particle suffers a large change in  $a$  and  $e$  [1] going to a new  $a$  of 10.7 AU and  $e$  of .461. With a aphelion of 15.6 AU the particle crosses the orbit of Saturn at 9.5 AU by an ample margin.

Fig. 1 shows the first 80,000 years of orbit evolution of a 2 micron particle released from Schwassman-Wachmann 1. This time history of semimajor axis shows early irregular motion the particle being scattered to nearly 20 AU before decaying under drag forces to a region near Saturn. There are a couple of ragged possible orbit resonances at about 10 AU before a finally scattering causes the particle to settle into 35,000 year 1 to 1 resonance capture at an interior point with Saturn. This interior resonance has semimajor axis  $a_i$  located by  $a_i = (1 - \beta)^{1/3} a_p$ , where  $\beta$  is the ratio of gravitational to radiation force and  $a_p$  is the planetary semimajor axis. This one to one resonance is located at  $a = 8.53$  AU for the 2 micron particle. Fig 2. shows detail of the time history of capture of semimajor axis during resonance capture. We see a quasi-saw-tooth pattern of co-rotation resonance.

In Fig. 3 we plot the motion of the dust particle in a rotating frame with respect to Saturn. Early on the particle is captured into a region around the L5 Lagrange point. (The location of this Lagrange point is however modified by radiation pressure [3].) However it librates about this point with an unusual amplitude finally migrating around to another quasi-stable libration about the L4 Lagrange point Fig 4. The trapping resonance is stable for about 35,000 years before breaking out. These instabilities in the trapping location and amplitude are probably due perturbations by Jupiter and weak instability of this 1:1 resonance cause by the Poynting-Roberston drag [3].

[1] Jackson, A and Zook, H., *Icarus*, **97** , 70 - 84 (1992), [2] Marsden, B, *Catalog of Cometary Orbits*, 1989. [3] Schuerman, D , *Ap. J.*, 337-342 (1980).

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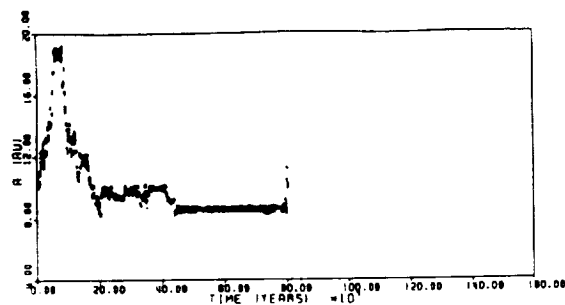


Figure 1. Time history of semimajor axis of a 2 micron particle released from Comet Schwassman-Wachmann 1. Time in thousands of years and semimajor axis in AU.

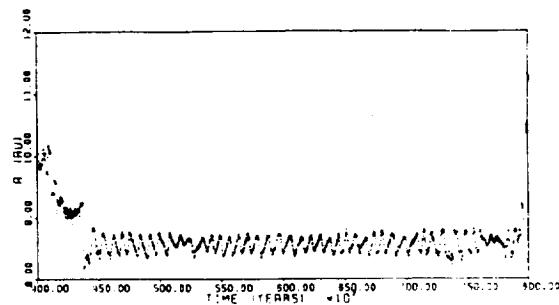


Figure 2. Detail from Figure 1 of orbital evolution of 2 micron dust particle at and during capture into a 1 to 1 mean motion resonance w.r.t. Saturn.

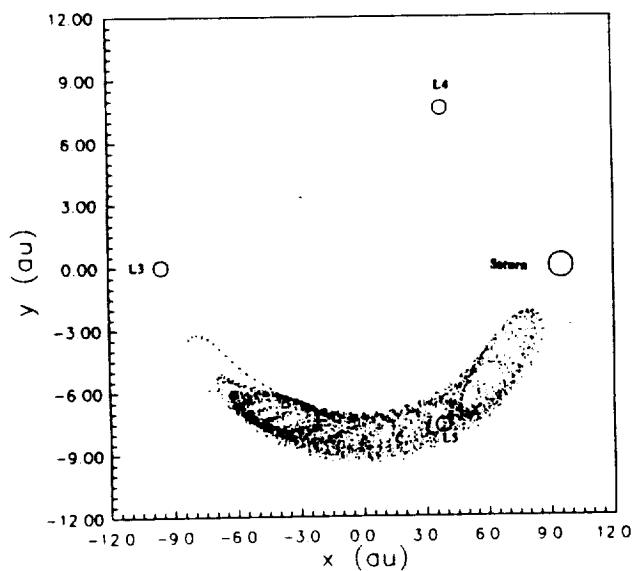


Figure 3. Early time history, about 4000 years into resonance, of orbit of 2 micron particle in a frame rotating with Saturn. There are wide quasi-librations about L5.

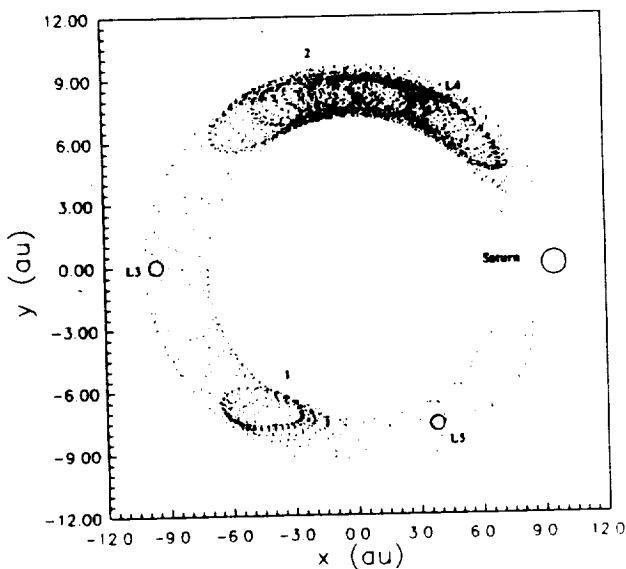


Figure 4. Subsequent history of particle evolution of Saturn rotating frame. The starts at point (1) and moves in a librating orbit towards Saturn then back towards (1) all the way around to near Saturn before settling down into quasi-libration around L4.