PLANETESIMAL DYNAMICS AT THE CENTER OF A RESONANCE. Glen R. Stewart, LASP, University of Colorado, Campus Box 392, Boulder, CO 80309.

The evolution of planetesimal swarms in unperturbed regions of the solar nebula have been modeled extensively by both n-body simulations and by kinetic theory [1, 2]. The dynamics of planetesimal swarms that are resonantly perturbed by a distant planet are not so well understood, in spite of numerous studies of resonantly perturbed planetary rings. The published work on planetary rings [3] is not directly relevant to planetesimal swarms because planetary ring models assume moderate to large collision frequencies that tend to damp out the nonlinear dynamics of resonant orbits. Alternatively, the collective self-gravity in planetary rings is assumed to be strong enough to excite spiral density waves that can also suppress the nonlinear dynamics of resonant orbits. However, planetesimal swarms in the asteroid belt and in the outer solar system that were resonantly perturbed by Jupiter most likely had very small collision frequencies and minimal collective self-gravity. Thus, whereas resonances in planetary rings exhibit orbital eccentricities that are linearly proportional to the mass of the perturbing moon, resonances in planetesimal swarms exhibit orbital eccentricities that are proportional to the cube root of the mass of the perturbing planet.

A kinetic theory for resonantly perturbed planetesimal swarms has been developed by expanding the Hamiltonian about the periodic orbit at exact resonance. In this approximation, planetesimal orbits simply oscillate about the resonant periodic orbits. Mutual interactions between planetesimals are modeled using a linearized collision operator. Various moments of the resulting kinetic equation yield differential equations for the average eccentricity and phase of the planetesimal orbits as well as an evolution equation for the rms relative velocity between the planetesimals. In addition, an equation is derived that describes the rate of migration of orbits toward or away from resonance.

The above theory can be used to test a scenario for the formation of Saturn. It has been proposed that planetesimals can be trapped in the exterior resonances of Jupiter where their mutual accretion is enhanced [4]. Trapping in exterior resonances is known to occur in the presence of gas drag [5] and may occur in weakly collisional swarms [6]. Eventually the planetesimals grow so large that their mutual perturbations scatter them out of the resonances, but the final surviving body has a semimajor axis close to Saturn's. In reference [4], an artificially enhanced gas drag was introduced to aid the capture of planetesimals into resonances. The kinetic theory described in this abstract allows us to evaluate the role of planetesimal collisions and energy equipartitioning due to dynamical friction. In particular, one can estimate the total mass of planetesimals that is required to allow resonant trapping during the accretion process.

PLANETESIMAL DYNAMICS AT RESONANCE
Stewart, G.R.

REFERENCES:
[1] Ida, S. and Makino, J. (1992), *Icarus* **96**, 107. [2] Stewart, G.R. and Wetherill, G.W. (1988), *Icarus* **74**, 542. [3] Shu, F.H. et al. (1985), *Ap. J.* **299**, 542. [4] Beauge, C., Aarseth, S.J., and Ferraz-Mello, S. (1994), *M.N.R.A.S.* **270**, 21. [5] Malhotra, R. (1993), *Icarus* **106**, 264. [6] Hanninen, J. and Salo, H. (1994), *Icarus* **108**, 325.