DYNAMICAL EFFECTS OF COMETARY BOMBARDMENT OF SATURN'S RINGS AND MOONS

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EXTENDED ABSTRACT. Saturn's ring particles and airless moons are exposed to a large flux of interplanetary debris, principally comets and comet dust. Collisions with this debris are responsible for both physical and dynamical changes in objects orbiting about Saturn. Physical changes include cratering of large bodies and catastrophic disruption of small bodies. Dynamical changes, which are analyzed in this paper, include orbital alteration (principally of ring particles) and changes in spin state (which are only important for moons, as ring particle spins are continually altered by mutual collisions).

Saturn's rings are rapidly being eroded by impacts of hypervelocity meteoroids in cometary orbits. Ejecta from these impacts will, in most cases, remain in orbit about Saturn and eventually be reaccreted by the rings, possibly at a different radial location. The resulting mass transport has been suggested as the cause of some of the features observed in Saturn's rings (see Durisen 1984 for a review). Previous attempts to model this transport have used numerical simulations which have not included effects of angular momentum transport coincident with this mass transport. I have developed an analytic model for ballistic mass transport in Saturn's rings. The model includes the effects of angular momentum advection and shows that the net material movement due to the combined effects of mass and angular momentum transport is roughly half that calculated when angular momentum advection is ignored. See Lissauer (1984) for further details.

All of Saturn's mid-sized moons are rotating synchronously with their orbital period; thus, the same hemisphere of these moons always faces the planet, and the same point is always at the center of the satellite's leading hemisphere (the apex). The satellites orbit Saturn with velocities ranging from 14 km/sec for Mimas to 8.5 km/sec for Rhea and 3.3 km/sec for Iapetus. These speeds are a significant fraction of the encounter velocities between comets and the Saturn system ($\sim$10-25 km/sec); thus, due to a type of "windshield effect" (more raindrops hit the windshield of a moving car than hit the rear window), more comets will collide with the moons' leading hemispheres than with their trailing hemispheres; also, higher relative velocities between comets

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and the moons will lead to larger craters for impacts by comets of a given mass on the leading hemispheres. The combination of these effects suggests that regions of the satellites' surfaces near the apex should be much more heavily cratered than regions near the antapex (Shoemaker and Wolfe 1982). Such a major cratering asymmetry has not been observed (Plescia and Boyce 1983). A similar situation exists for Jupiter's moons Ganymede and Callisto (Passey and Shoemaker 1982).

McKinnon (1981) suggested that stochastic reorientation of the moons by impact-induced "spinup" during the establishment of the cratering record tended to equilibrate the crater densities between hemispheres. I have re-examined the dynamics of this problem, and I conclude that most impacts large enough to have caused "spinup" would have catastrophically disrupted the moons in question (Lissauer 1985).

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