INVESTIGATIONS OF PLANETARY RING PHENOMENA

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Faint planetary rings--their dynamical behavior and physical properties--have been the main focus of research efforts during the past year. A reanalysis of the structure and physical properties of the Jovian ring system was completed and will be published shortly (2). Jupiter's ring is composed of i) a flattened main ring ($t \lesssim 300$ km) that terminates abruptly at its outer edge, and that has features associated with the two known embedded moonlets, ii) a toroidal halo that rises quickly at the main ring's inner edge to a half thickness of $\sim 10^4$ km and fades into the background at $\sim 1.4\ R_J$, and iii) the exterior "gossamer" ring (see last year's progress report) that is only 1/20 as bright as the main ring and that is enhanced at synchronous orbit. The ring is reddish like nearby Amalthea and its particles have a power law size distribution of slope $-2.5(\pm 0.5)$ in the range ~ 0.1-100μm.

We have examined the motion of weakly-charged dust through Jupiter's gravitational and magnetic fields (1). Resonances occur where the frequency of the perturbing Lorentz force matches a grain's natural orbital frequency; near such resonances, large radial and out of plane motions appear. Ongoing research shows that during passage through such resonances large vertical amplitudes develop and persist; the boundaries of the jovian halo are near such locations. Current studies include the character of stochastic variations in a particle's electric charge and the orbital consequences of this, an analytical investigation of resonance passage, the details of the dust-plasma interaction, and application to other ring systems.

Several topics concerning features of Saturn's rings have been addressed. Cuzzi and Burns (4) have shown that depletions in MeV charged particles measured by Pioneer 11 near the F ring are only partly caused by the ring and thus that unobserved localized clouds of debris must be present. We hypothesize that these faint clouds are ejecta thrown off during collisions amongst moonlets (radius 0.1-10 km) which populate the entire annulus between the orbits of the shepherds. We have developed a self-consistent scenario in which mutual collisions of unseen parents generate debris clouds, which then shear out and become part of an overall patchy background of faint material; the particles comprising the background are continually re-accreting onto the parents, only to be thrown off in some later collision. According to this model, about 10^2 clouds (with $\tau \sim 10^{-3}$-10^{-4} and $\sim 10^2$ km$\times 10^4$ km size) should be present at any typical time. With a steep size distribution of parents, even the F ring itself could be the outcome of a collision between two of the largest moonlets, in which case the F ring is a temporary feature of the ring system. We suggest that arcs like those in

Neptune's retinue may be produced by this scheme. Kolvoord (7) has developed a perturbation routine to study the orbital consequences of an embedded moonlet on a narrow ring and is presently incorporating an exterior satellite perturber into his program as well as considering the consequences of particle collisions within the narrow rings.

Showalter and co-workers (3) have interpreted quasi-periodic optical depth variations that were found on either side of the Encke gap as the gravitational "wakes" of a moonlet orbiting near the gap's center and at a longitude of 32°. A single moonlet of ~10 km radius is able to produce the observed features. Studies of the signal scatter of the PPS occultation data by Showalter and Nicholson (8), initiated under this grant, give promise of providing an independent measure of the size distribution of ring particles.

The origin and fate of Uranian ring dust is presently being studied (6). Such ring particles have brief lifetimes primarily due to sputtering and orbital collapse under atmospheric drag. An unresolved quandary is that abrupt transitions in ring brightness observed at interior ringlet edges seem to imply that the expected orbital evolution does not proceed. The dust discovered on ring plane crossing at 4.57 R_U must have nearby sources; its broad and asymmetric distribution about the planet's equatorial plane suggests that resonant electromagnetic forces are at work (5).

Our studies of faint rings are pertinent to the possible presence of fine material near Neptune; such grains could prove hazardous to Voyager 2 as it swings through the ring plane on its way toward a flyby of Triton; we have been helping to advise the Voyager project office on the potential danger to this precious spacecraft.

Several review articles were also prepared during the funding period. They concerned dust motion (9), planetary rings (10), satellites (11), and satellite orbital evolution (12).

1. L. Schaffer and J.A. Burns (1986). The dynamics of weakly-charged dust: Motion through Jupiter's gravitational and magnetic fields. Jnl.Geophys.Res. 92, in press. Abstracts in BAAS 17, 921; BAAS 18, 777-778 and 838, Nat'l Congress Applied Mech. Paper F3a (Austin, June 1986).

2. M.R. Showalter, J.A. Burns, J.N. Cuzzi and J.B. Pollack (1986). Jupiter's ring system: New results on structure and particle properties. Icarus 69, in press.

3. M.R. Showalter, J.N. Cuzzi, E.A. Marouf and L.W. Esposito (1986). Satellite "wakes" and the orbit of the Encke gap moonlet. Icarus 66, 297-323.

4. J.N. Cuzzi and J.A. Burns (1986). Charged particle depletion surrounding Saturn's F Ring: Evidence for a moonlet belt. Icarus, submitted; Abstracts in BAAS 17, 922; 18, 768; EOS 67, 1077.

5. D.A. Gurnett, W.S. Kurth, F.L. Scarf, J.A. Burns, J.N. Cuzzi and E. Grun (1986). An analysis of micron-sized particle impacts detected near Uranus by Voyager 2. Jnl.Geophys.Res., in preparation; Abstract in EOS 67, 340.

6. J.A. Burns, L.E. Schaffer, J.N. Cuzzi, and D.A. Gurnett (1986). Dust in the Uranian system: Its origin and fate. BAAS 18, 770-771.

7. R.A. Kolvoord (1986). The effect of an embedded satellite on narrow rings using a perturbation approach. BAAS 18, 771.

8. M.R. Showalter and P.D. Nicholson (1986). Saturn's rings through a microscope: Constraints on particle size from the Voyager PPS scan. BAAS 18, 767.

9. J.A. Burns (1986). The motion of interplanetary dust. In Evolution of the Small Bodies in the Solar System (M. Fulchignoni and L. Kresak, Eds.), in press.

10. J.A. Burns (1986). Rings around planets. In Evolution of the Small Bodies in the Solar System (M. Fulchignoni and L. Kresak, Eds.), in press.

11. J.A. Burns (1986). Some background about satellites. In Satellites (J.A. Burns and M.S. Matthews, Eds.), University of Arizona Press, 1-38.