JOURNAL OF THE KOREAN ASTRONOMICAL SOCIETY
29: S355 ~ S355, 1996

THE DYNAMICS OF SATURN'S RINGS

EVGENY GRIV AND CHI YUAN
Institute of Astronomy & Astrophysics, Academia Sinica, PO Box 1-87 Nankang, Taipei, Taiwan 11529, R.O.C.

Voyager images of the Saturnian ring system have shown evidence of a great deal of structure (Smith et al. 1982). The best resolution was attained during an experiment on board the Voyager 2 spacecraft on the stellar occultation measurements by the photopolarimeter and demonstrated structures at all scales, down to the limit of resolution. As was stated by Esposito (1986): "every time we improve our resolution we see more structure."

According to observations, most of the structures are irregularly spaced and do not correspond to resonances with known satellites (Goldreich & Tremaine 1982). It has been suggested that a part of the small-scale irregular structure may be due to embedded moonlets orbiting within the ring system (Lissauer et al. 1981). As a matter of fact, a small moon, Saturn's eighteenth satellite has recently been discovered embedded within the Encke gap of the ring system (Showalter 1991). But of course, this observation does not imply that most of the irregular structure in the rings results from moonlets; other mechanisms may also be proposed. For instance, there exist features in the rings which can be associated with resonant forcing by external moons (Goldreich & Tremaine 1982; Shu et al. 1983).

However, it is important to note that on a small scale the rings have been observed to be undergoing variation and oscillations with time and ring longitude (Smith et al. 1982). The latter indicates that probably such features are *wave* phenomena, and different *instabilities* of small-amplitude oscillations may play decisive roles in ring's dynamics.

In the present work, current ideas about the wave origin and evolution of planetary rings are examined. In particular, the dynamics of planetary rings under the effect of collisions between particles is considered. The theory is relevant to discussing the physics of low optical depth regions, that is, of a system with rare interparticle collisions, which are observed in the C ring, the A ring and in the inner portions of the B ring in the Saturnian ring system. Kinetic theory with the Boltzmann and Poisson equations is used to obtain the eigenfrequencies of oscillations propagating in the plane of the system. In the case of rare collisions the resulting kinetic equation for the perturbed distribution function can be solved by successive approximations, neglecting the effect of binary particle collisions in the zeroth-order approximation. The effects of physical (inelastic) collisions between particles are taken into account by using a phenomenological Bhatnagar, Gross, and Krook model collisional operator.

The investigation is made on the basis of the analogy to magnetized plasma problems. (On a formal analogy between the oscillations in a rotating self-gravitating disk of point masses and the oscillations of a hot one-component nonneutral plasma in a magnetic field see, e.g., Griv & Peter [1996].) Different instabilities in such a system on scales of the order of the ring thickness are considered. A mechanism for the irregular, small-scale $\lesssim$ 100 m structure in regions of low optical depth in Saturn's rings is proposed. It is suggested that Cassini spacecraft high-resolution images of low optical depth regions will show this kind of structure in the Saturnian ring system almost a decade from now.

The main results of our work have been published (Griv 1996; Griv & Chiueh 1996; Griv & Yuan 1996) or submitted to publication (Griv et al. 1996) [see also Shu et al. (1985) and Griv & Peter (1996)].

REFERENCES

Esposito, L.W. 1986, Icarus, 67, 345

Goldreich, P., & Tremaine, S. 1982, Ann. Rev. Astron. Astrophys., 20, 249

Griv, E. 1996, Planet. Space Sci., 44, 579

Griv, E., & Chiueh, T. 1996, Astron. Astrophys., 311, 1033

Griv, E., & Peter, W. 1996, Astrophys. J., 468, in press

Griv, E., & Yuan, C. 1996, Planet. Space Sci., 44, in press

Griv, E., Yuan, C., & Chiueh, T. 1996, Planet. Space Sci., submitted

Lissauer, J.J., Shu, F.H., & Cuzzi, J.N. 1981, Nature, 292, 707

Showalter, M.R. 1991, Nature, 351, 709

Shu, F.H., Cuzzi, J.N., & Lissauer, J.J. 1983, Icarus, 53, 185

Shu, F.H., Dones, L., Lissauer, J.J., Yuan, C., & Cuzzi, J.N. 1985, 299, 542

Smith, B.A., Soderblom, R., Batson, R., et al. 1982, Science, 215, 504