Geophysical Research Abstracts, Vol. 7, 00692, 2005
SRef-ID: 1607-7962/gra/EGU05-A-00692

Stability and structure of Saturn's rings: three-dimensional effects

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Stability and structure of Saturn's main A, B, and C rings is examined with reference to the experiments of the NASA/ESA space probe Cassini. A new analytical method is given for the solution of the self-consistent system of the Boltzmann kinetic equation and the Poisson equation describing the stability and evolution of the self-gravitating three-dimensional particulate disk of Saturn's main rings. The solution is obtained when the disk is perturbed in an arbitrary manner, that is, when gravity perturbations (e.g., those produced by a spontaneous disturbance or a satellite system) do not distort the disk's equatorial plane (even Jeans-type perturbations) or when gravity perturbations distort the disk's plane (odd bending firehose-type perturbations). As an application of the method, the modifications introduced for the properties of fine-scale $\sim$ 100 m or even less density waves of the kind studied by Lin & Shu (1964, 1966), Lin et al. (1969), and Shu (1970) in connection with the problem of galactic spiral structure is considered. Local three-dimensional N-body simulations are described to verify the validities of the theory. An account of some observable effects connected with the small but finite thickness of Saturn's rings is given as well.

Acknowledgements. This work was supported in part by the Israeli Ministry of Immigrant Absorption, the Israel Science Foundation, the Binational U.S.–Israel Science Foundation, and the Academia Sinica in Taiwan.