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

E. Griv (1), M. Gedalin (1) and C. Yuan (2)

(1) Department of Physics, Ben-Gurion University, Beer-Sheva 84105, Israel (griv@bgu.ac.il), (2) Institute of Astronomy and Astrophysics, Academia Sinica, Taipei 23-106, Taiwan

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 of the self-gravitating three-dimensional particulate disk of Saturn's main rings. A general solution is obtained when the disk is perturbed in an arbitrary manner, that is, when small-amplitude gravity perturbations (e.g., those produced by a spontaneous disturbance or a satellite system) do not distort the the disk's plane (even Jeans-type perturbations) and when gravity perturbations distort the disk's plane (odd bending-type or firehose-type perturbations). As an application of the method, the modifications introduced for the properties of fine-scale ~ 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 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.

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