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# Fine-Scale Density Wave Structure of Saturn's Rings: A Kinetic Theory

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## Abstract

This article reviews recent studies of morphology and dynamics of low and moderately high optical depth regions of the Saturnian ring system of discrete mutually gravitating particles with special emphasis on its fine-scale of the order of 100 m structures (almost regularly spaced, aligned cylindric density enhancements and optically-thin zones with the width and the spacing between them of roughly several tens particle diameters). We explain the very existence and the value of the critical wavelength $\lambda_{crit} \lesssim 100$ m of the fine structure in a local version of kinetic stability theory. It is shown that there is a dominant Fourier mode of maximum instability of Jeans-type collective oscillations in Saturns rings, and the associated number of spiral arms and the pitch angle. It appears very likely that some of the observed microstructures in Saturns A and B rings both axisymmetric and nonaxisymmetric ones are manifestations of these effects produced by Jeans gravitational instability. We argue that the quasi-periodic density enhancements are flattened structures, with height/width ratio of about 0.3 or even less. A separate investigation based on high-resolution of the order of 10 m observations of Saturns A and B (and probably C) rings should be done to confirm this prediction. It is also shown that the gravitational instability might be proposed as potential clusters-forming mechanism leading to formation of porous 100-meter-diameter moonlets of preferred mass $10^7$ g each embedded in broad rings, and this has yet to be directly measured. We again argue that sufficient velocity dispersion prevents the Jeans instability from occurring but inelastic interparticle collisions reduce the relative particle velocities so that the Jeans instability may be an effective generating mechanism for the recurrent fine structure of the ring system. The predictions of the theory are verified by $N$-body simulations of an orbiting patch of the ring. The stability analysis and simulations presented here would have to be regarded as an explanation of the ring structure in the range of few tens to few hundreds meters in regions of Saturns A, B, and C rings with optical depth $\tau < 2$ that has been found in recent Cassini spacecraft measurements.

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