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Intrinsic structure in Saturn's rings

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Abstract

Saturn's rings are the most prominent in our Solar system and one example of granular matter in space. Dominated by tides and inelastic collisions the system is highly flattened being almost 300000km wide while only tens of meters thick. Individual particles are composed of primarily water ice and range from microns to few tens of meters in size. Apparent patterns comprise ringlets, gaps, kinematic wakes, propellers, bending waves, and the winding spiral arms of density waves. These large-scale structures are perturbations foremost created by external as well as embedded moons.

Observations made by the Cassini spacecraft currently in orbit around Saturn show these structures in unprecedented detail. But high-resolution measurements reveal the presence of small-scale structures throughout the system. These include self-gravity wakes (50-100m), overstable waves (100-300m), sub-km structure at the A and B ring edges, "straw" and "ropy" structures (1-3km), and the C ring "ghosts". Most of these had not been anticipated and are found in perturbed regions, driven by resonances with external moons, where the system undergoes periodic phases of compression and relaxation that correlate with the presence of structure. High velocity dispersion and the presence of large clumps imply structure formation on time scales as short as one orbit (about 10 hours).

The presence of these intrinsic structures is seemingly the response to varying local conditions such as internal density, optical depth, underlying particle size distribution, granular temperature, and distance from the central planet. Their abundance provides evidence for an active and dynamic ring system where aggregation and fragmentation are ongoing on orbital timescales. Thus a kinetic description of the rings may be more appropriate than the fluid one.

I will present Cassini Ultraviolet Spectrometer (UVIS) High Speed Photometer (HSP) occultations, Voyager 1 and 2 Imaging Science Subsystem (ISS), and high-resolution Cassini ISS images. I will discuss the kinematics of the A and B ring edges and their deviations from their expected m=2 and m=7 lobed patterns, show wavelet signature and morphology of sub-km structure found at these edges and in strong density waves, and illustrate observed characteristics of the C ring "ghosts" as well as self-gravity wakes in the A and B ring.

Finally I will review our current theoretical understanding of the small-scale structure and size distribution of Saturn's rings with respect to particle-particle collisions, aggregate stability, and kinetic modeling.

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