A SEASON IN SATURN'S RINGS: CYCLING, RECYCLING AND RING HISTORY.

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Introduction: Cassini experiments have watched Saturn's ring system evolve before our eyes. Images and occultations show changes and transient events. The rings are a dynamic and complex geophysical system, incompletely modeled as a single-phase fluid.

Key Cassini observations: High resolution images show straw, propellers, embedded moonlets, and F ring objects. [1] Multiple UVIS, RSS and VIMS occutlations indicate multimodal ringlet and edge structure, including free and forced modes along with stochastic perturbations [2] that are most likely caused by nearby mass concentrations. Vertical excursions are evident at ring edges and in other perturbed regions. The rings are occasionally hit by meteorites that leave a signature that may last centuries. Temperature, reflectance and transmission spectra are influenced by the dynamical state of the ring particles.

Saturn's Equinox 2009: Oblique lighting exposed vertical structure and embedded objects. [3] The rings were the coldest ever. Images inspired new occultation and spectral analysis that show abundant structure in the perturbed regions. The rings are more variable and complex than we had expected prior to this seasonal viewing geometry.

Sub-kilmeter structure in power spectral analysis: Wavelet analysis shows features in the strongest density waves and at the shepherded outer edge of the B ring. Edges are variable as shown by multiple occultations and occultations of double stars. [4]

F ring kittens: 25 features seen in the first 102 occultations show a weak correlation with Prometheus location. We interpret these features as temporary aggregations. Simulation results indicate that accretion must be enhanced to match the kittens' size distribution. [5] Images show that Prometheus triggers the formation of transient objects. [6]

Propellers and ghosts: Occulations and images provide evidence for small moonlets in the A, B and C rings. These indicate accretion can occur inside the classical Roche limit.

Implications: Self gravity causes wakes, viscosity, overstability and local aggregate growth. Nearby moons and resonant forcing drive the ring system away from equilibrium through streamline crowding, which allows enhanced accretional growth. Structures form and disappear at length scales from meters to kilometers, on time scales of hours to months. This cyclic behavior resembles an ecological predator-prey system or a boom-and-bust economic cycle. In such an agitated stochastic system, solid bodies may represent the absorbing states of a Markov chain: rare events can produce a distibution with many transient but a few long-lasting bodies. [4] These bodies would preferentially form at shepherded ring edges near the Roche limit, as hypothesized by Charnoz. [7] These large bodies can sequester material in their interiors, reducing the amount of meteoritic ring pollution and recycling the ring material into new rings. Such processes would allow the rings to be as ancient as the solar sytem. [8]

References:

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