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Cassini UVIS observations: structure and the history of Saturn's rings

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Cassini observations show unexpected ring variability in time and space. Time variations are seen in ring edges, in the thinner D and F rings, and in short-lived agglomerations. The rings are inhomogeneous, with structures on all scales, sharp gradients and edges. Compositional gradients are sharper than expected, but nonetheless cross structural boundaries. This is evidence for ballistic transport that has not gone to completion. The rings are so pure ice that little evidence exists for pollution by meteoritic material. The autocovariance maximizes in the middle of the A ring, with smaller structure near the main rings' outer edge. Density wave locations have a fresher ice composition. The processes of collisions, diffusion and transport should have homogenized the rings over the age of the solar system. Instead, these differences persist. The mass density in the Cassini division inferred from density waves is so low, that the material there would be ground to dust in 30,000 years. The observed moons that cause such interesting structure in the rings have short lifetimes against disruption by cometary bombardment and against the angular momentum transfers that push them away from the rings. Self-gravity wakes and overstability are evident in the main rings.The rapid processes evident in the Cassini data have been taken as evidence that the rings were recently created, perhaps from a comet that passed too close to Saturn. Instead, an alternative is that primordial material may have been re-used and recycled. In the zone near the Roche limit where rings are found, limited accretion is possible, with the larger bodies able to recapture smaller fragments. The 'propeller' structures, the self-gravity wakes, and the size distribution of clumps in Saturn's F ring are all indications of the on-going accretion process. Recycling could extend the ring lifetime almost indefinitely. The range of ages, the variety evident in the latest observations and the low mass density inferred for the largest bodies are consistent with extensive recycling of ring material as the explanation of the apparent youth of Saturn's rings. Similar processes are likely occurring in the other ring systems and in the formation of planets around other stars. Particularly, such processes could be important where more rapid growth is frustrated, as in the asteroid belt and the Kuiper belt.