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# History of Saturn's rings

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Cassini observations show unexpected ring variability in time and space. 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. 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, under-dense embedded moons, and 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. If the rings are more massive than previously expected, particularly the B ring, the ring ice can still appear pristine now. Perhaps the other rings like ring A are younger. The Pioneer 11 charged particle data can be consistent with five times more mass, because we now know that the self-gravity wakes make the ring highly heterogeneous.