EPSC Abstracts,
Vol. 2, EPSC2007-A-00092, 2007
European Planetary Science Congress 2007

Clumps and Moonlets in Saturn's F Ring

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Stellar occultations of Saturn's F ring detect nine statistically significant events, ranging in width from 27m to 9km, that indicate temporary aggregation of ring material. One event is also seen by VIMS. At least one event is elongated: these structures may cause temporary brightenings as seen by Voyager, Hubble, and Cassini. At least one, and perhaps two of the structures are opaque to starlight, indicating a number of small moons, as predicted by models that match Pioneer and Voyager data. These moons may be accompanied by long streaks of trailing debris, as shown in simulations by Lewis and Stewart. Even if these temporary aggregations are "seeded" by larger particles that are fragments of shattered moons, such objects have very short lifetimes against disruption. Thus, unless Saturn's F ring was created in the last few million years, a competing process of re-accretion must balance the destruction. This hypothesized "recycling" allows the F ring to be much more ancient. Similar features of propellers and under-dense moons in and around the main rings also require similar recycling, or a very recent formation. The range of ages indicated by Cassini observations are much easier explained by ongoing fragmentation and recycling through accretion, than by a single recent formation event. The high fraction of ice evident in ring spectra cannot be explained purely by coating their surfaces: CRAND observations and Mimas surface contradict this hypothesis. This purity of the rings against meteoritic infall can be consistent with the model of ancient rings if the meteoritic influx is overestimated or the ring mass has been underestimated. In that case, the rings could be primordial. Now they are continually recycling material, and would likely persist long into the future, but not exactly as we see them now.