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Dynamical Evolution of Saturn's Rings Driven by Micrometeoroid Bombardment

After more than a dozen years in orbit about Saturn, the Cassini mission provided key measurements that are important for determining the age of Saturn's rings. These include the extrinsic micrometeoroid flux at Saturn, the volume fraction of non-icy pollutants in the rings, and the total ring mass. These factors help to constrain the ring age to be no more than a few 100 Myr. The Cassini Grand Finale also provided a suite of observations that demonstrate that the rings are losing mass to the planet at a surprising rate. Some of the mass flux falls as "ring rain" at higher latitudes consistent with the H3+ infrared emission pattern thought to be produced by an influx of charged water products from the rings. The contribution needed to account for the ring rain phenomenon though is considerably less than the total equatorial measured mass influx of 4800 – 45000 kg/s. Taken together, these observations imply that the rings are not only young, but also ephemeral. Here we demonstrate that bombardment by micrometeoroids, and ballistic transport of their impact ejecta can account for these observations. That is, assuming the rings began as pure ice, incoming non-icy micrometeoroids can darken the rings to their current state in the given timescale, while the dynamical effects of this bombardment process can concomitantly produce the observed mass inflow rates implying the rings were initially more massive than today. Such high continuous mass loss also suggests the rings may effectively disappear in no more than a few 100 Myr.