The consequences of Saturn’s “ring rain”

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Saturn’s upper-atmospheric H3+ emissions have been previously studied using ground-based observations, and found to exhibit peaks in emissions at specific latitudes. The cause of these peaks is due to an influx of charged water products originating from Saturn’s rings known as 'ring rain'. Subsequent modeling using the Saturn Thermosphere Ionosphere Model (STIM) has indicated that these peaks in H3+ emissions are likely driven by an increase in H3+ density, rather than temperature, as a local reduction in electron density (due to charge exchange with water) lengthens the lifetime of H3+. However, a direct observation of the H3+ density is required to estimate the flow rate of material into Saturn with models. Calculation of ring rain’s flow rate into Saturn is a highly important input for determining the age, lifetime and evolution of Saturn’s rings.

Here we present the first ever derivation of H3+ density, temperature and radiance in the non-auroral regions of Saturn, using data taken from the 10-meter Keck telescope in 2011. H3+ density is enhanced near 45 degrees north planetocentric latitude and strongly reduced near 39 degrees south. When compared to STIM modeling results, these densities indicate a small ~50kg/sec water influx in the north and an enormous ~1500 kg/sec influx in the south. The charged grains are pulled in along the magnetic field by gravity, but the southward-inclination of the magnetic field (in the vicinity of the ring plane) means that the grains are preferentially drawn southwards into the planet. Assuming that our (Saturn northern Springtime) measurement represents all seasons, and that the rings are able to disperse over time, the ring rain mechanism alone will drain Saturn’s rings to the planet within 300 million years. If we also add the recent Cassini-spacecraft measured ring-material detected falling into Saturn’s equator (and assume it is constant), then the rings have less than 100 million years to live.

Recent measurements by Cassini again have estimated a ring age of ~50 million years, so it seems that Saturn’s rings are short-lived phenomena, perhaps lasting just 150 million years in total. A long time on human timescales, but compared to the 4.5 billion year age of Saturn, the rings are essentially temporary; i.e. if Saturn were 30 years old, the ring system would exist for just 1 year of its life! These recent findings indicate that ring systems in general are practically doomed to be removed as soon as they are formed. Indeed, the ring rain mechanism itself ought to be universal at any planet with both a ring system and a strong magnetic field. We might ask, did Jupiter, Uranus and Neptune, which have thin rings today, once have magnificent rings in the past that have eroded away?

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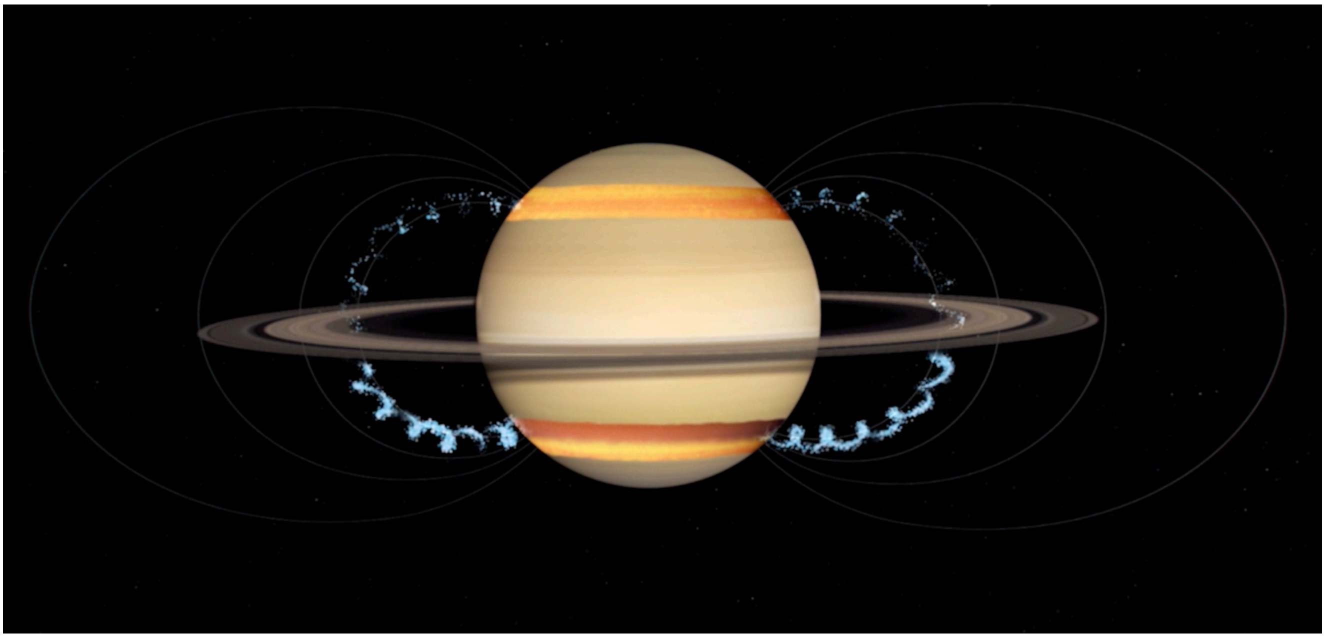

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