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Compositional Evolution and Age of Saturn's Rings

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Abstract

Saturn's rings are constantly bombarded by exogenous meteoritic material. Over time, this bombardment changes the composition of the ring system in ways that are detectable via UV spectroscopy using Cassini UVIS data. Spectroscopic analysis can tell us the current fractional pollution of the rings, but cannot tell us about the history of the rings. If we want to know something of the age and history of the ring system, then we need a model which describes the bombardment of the rings over time.

We present an update to our Markov-chain based model [1] for bombardment of Saturn's rings. The model calculates the fractional pollution of the rings by meteoritic material over time and is dependent upon the infalling mass flux of this material as well the surface mass density of the ring being impacted. We include effects due to the optical depth of the ring, such as particle shielding from impactors in high optical depth regions. We also incorporate the latest results reported by the Cassini CDA team [2] regarding the mass flux entering the system. Understanding this mass-flux is critical to understanding the evolution of the rings.

Comparison of our model result to the current state of the rings (that is, to UVIS Spectra) allows us to estimate the age of the rings.

1. Markov-Chain

Our Markov-chain based model simulates the growth of a layer of regolith on the surfaces of ring particles. As impactors excavate material from the ring particles, the material is redeposited as a broken-up regolith layer. If an impactor is large enough to excavate through the regolith layer, new fresh icy material is added to the regolith layer, in addition to the meteoritic material, causing the regolith layer to grow in depth. If the impactor is too small to excavate through the regolith layer then the regolith layer becomes more polluted and only grows by a small amount. This simulation yields a time-series of fractional pollution of the ring particles.

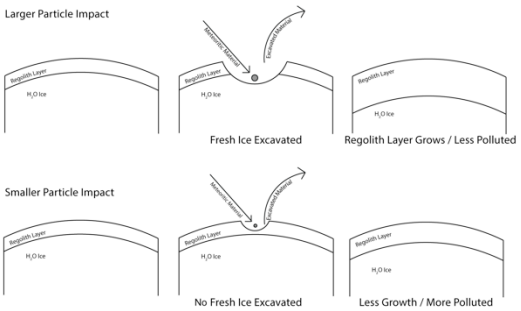

Figure 1: Illustration of regolith growth.

2. Spectroscopy

We then perform a non-linear least-squares fit to Cassini UVIS spectra, using Hapke's 2012 [3] model for bidirectional reflectance of an intimate mixture of regolith grains, to calculate the current fractional pollution of the ring particles. We examine two different pollutants, amorphous carbon, and cometary material as measured by the Rosetta Alice UV spectrometer of comet 67P/Churyumov–Gerasimenko [4]. This fit yields a fractional pollution value which can be compared to our Markov model result in order to estimate the age of the rings.

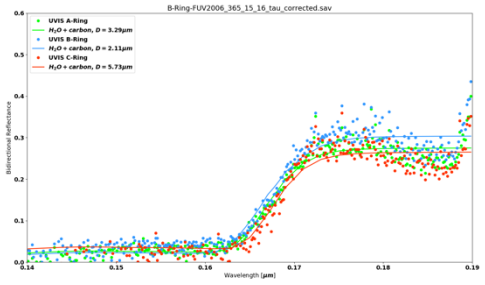

Figure 2: Example fit to UVIS data for A, B and C rings.

3. Summary

We present an updated estimate for the age of Saturn's ring system based upon our bombardment simulation and analysis of UVIS spectra of the rings. Best fit spectra are computed for the A, B and C rings in order to make a comparison of each region with regard to fractional pollution and age.

References

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