HST-STIS Spectra of Saturn's Rings and Implications for Their Reddening Agent

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Abstract

We obtained HST-STIS spectra of Saturn's main rings in May 2011, using the G230L (and G430L) gratings, with final averaged radial resolution of 160 (and 330) km/pixel. The dataset filled a previous 200-330nm "spectral gap" between Cassini and ground-based spectra. The data provide radial profiles as a function of wavelength, but our most basic product at this point is a set of very low-noise spectra, radially averaged over broad regions of the rings (A, B, C, and Cassini Division). The raw spectra required special processing to remove artifacts due to extended-source grating scatter. We have modeled the spectra using a new particle surface model, which corrects for on-surface shadowing due to the likely very rough ring particle surfaces, and avoids overestimation of intra-mixed "neutral absorber". We correct for non-classical layer effects and finite ring optical depth, and relate our observed reflectivities to the spherical albedos of individual smooth particles. We model these smooth particle albedos using standard Hapke theory for regolith grain mixtures that are either homogeneous and "intramixed" (nonicy absorbers dispersed in water ice regolith grains) or heterogeneous "intimate" mixtures. As candidates for the nonicy contaminants we have considered amorphous carbon, aromatic-rich and aliphatic-rich organic tholins, silicates, hematite and iron metal. For the A and B rings, we find that iron metal (including a new theoretical estimate of the refractive indices of nanometer-sized grains of iron) is not spectrally steep enough in the 200-300nm range, and that aliphatic-rich tholins are either too steep at short wavelengths or too flat at long wavelengths. However, less than 1% by mass of aromatic-rich tholins provides a very good fit across the entire spectral range with no gratuitous "neutral absorber" needed, and a minimum of additional free parameters. The best fits require forward-scattering regolith grains. For the C Ring and Cassini Division, additional absorbers are needed (updated results will be given).