

COMBINING NEW LABORATORY STUDIES AND CASSINI CIRS DATA ANALYSIS TO DETERMINE THE COMPOSITION AND TEXTURE OF SATURN'S RINGS. C. R. Nugent¹, M. S. Gudipati², L. J. Spilker², S. G. Edgington², S. H. Piorz², C. Leyrat², N. Altobelli³, C. T. Russell⁴. ¹Department of Earth and Space Sciences, University of California, 595 Charles Young Drive East, Los Angeles, CA 90095 (cnugent@ucla.edu), ²JPL, 4800 Oak Grove Dr. M/S 230-205, Pasadena, CA 91109, ³European Space Agency, European Space Astronomy Centre, P.O. Box - Apdo. de correos 50727, Madrid, 28080, Spain, ⁴Institute of Geophysics and Planetary Physics, UCLA, 405 Hilgard Ave, Los Angeles, CA 90095.

Introduction: Spectra from Cassini's Composite Infrared Spectrometer (CIRS) is currently being used to investigate the composition and surface texture of Saturn's inner main rings over the wavenumber range of 10 to 600 cm^{-1} . These studies revealed spectral features which have not yet been identified in the laboratory. We present here a combined laboratory and modeling effort to obtain a deeper understanding of the processes that occur on the surfaces of Saturn's inner rings.

Spectral roll off: CIRS observations of Saturn's A, B and C rings have revealed a thermal emission spectral "roll-off" in the far-infrared. Below 50 cm^{-1} , the rings' spectra increasingly deviate from a black-body curve with decreasing wavenumber (Figure 1). Studies have shown that pure water-ice absorption cannot generate this roll-off [1], and this roll-off has never been observed in a laboratory setting.

Although the cause of this roll-off is unclear, previous studies have hinted that it could be due to a combination of the surface properties of the ice and the presence of impurities.

Ring Composition: Saturn's rings display a variety of colors when seen in visible light, indicating a complex composition (Figure 2). Efforts to isolate spectroscopic signatures due to materials other than water ice are still underway. Cassini's Ion and Neutral Mass Spectrometer has detected molecular and atomic oxygen near the A ring, which are perhaps part of a tenuous ring atmosphere [3]. Results from Cassini's Cosmic Dust Analyzer indicate the E ring is predominantly water ice, with minor contributions from possible combinations of silicates, carbon dioxide, ammo-

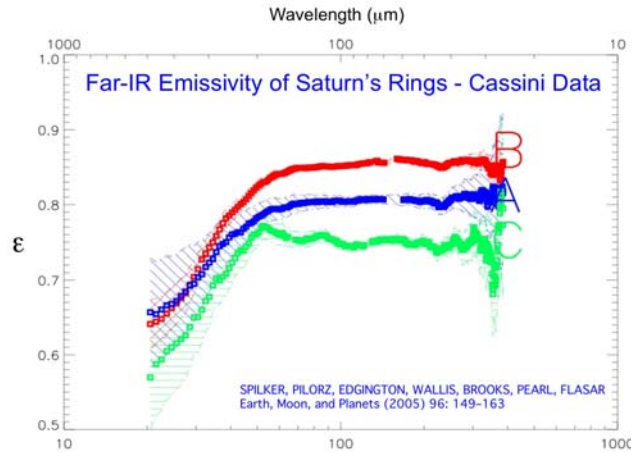
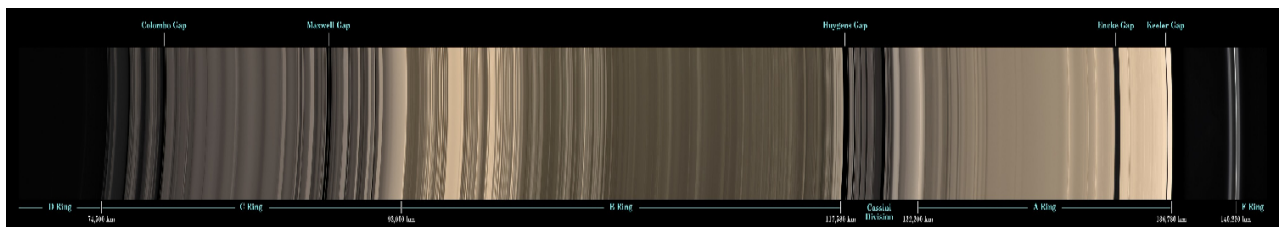


Figure 1: Ring emissivities of the A, B and C rings. Note that each ring system seems to have different spectral characteristics, but all show a roll-off below 50 cm^{-1} [1].

nia, molecular nitrogen, hydrocarbons and perhaps carbon monoxide [4].

The rings spectra observed by CIRS are a complicated combination of thermal emissions, the effects of scattering from ring particles (over a broad size distribution) and noise. Before the signal can be examined for the faint absorption features, the contributions of scattering and thermal emission must be accounted for and removed using Mie scattering and standard radiative transfer techniques. Since the signatures of the minor ring constituents are very faint, it is important to incorporate the highest quality experimental indices of refraction into the Mie code.

Figure 2: True color inner ring image from Cassini released on October 24, 2007. Color variations reveal the presence of materials other than water ice in the ring particles.



Laboratory Data: Far-infrared laboratory work designed to address these issues will be carried out in Murthy Gudipati's JPL laboratory. We plan to quantify and identify far-infrared ($20 - 500 \text{ cm}^{-1}$) spectral features of ices with and without impurities before and after laser and electron sputtering. Sputtering will be used to both simulate Saturn's magnetospheric environment and generate small-grained ice deposits on the surface of the ice. These far infrared spectra will then be correlated with the mid infrared ($400 - 4000 \text{ cm}^{-1}$) spectral features, optical constants will be derived, and a community-accessible database will be created.

Need for Further Laboratory Data: As shown in Figure 3, Mie scattering below 100 cm^{-1} is strongly modulated by the ice grain size. Laboratory far-infrared absorption and scattering data is needed for ice grains between 10 microns and a few millimeters in size.

Application to Icy Bodies: Though our focus is on Saturn's rings, it is expected that this new far-infrared data will be useful for studies of other icy solar system objects such as Europa, Enceladus, and Ganymede, as well as icy asteroids such as Ceres. If the experimental work confirms that the spectral roll-off below 50 cm^{-1} is due to a grain size distribution on the surface of the ice, we will have a new method to remotely determine the surface morphology of icy bodies.

References: [1] Spilker, L. J. et al. (2005) *Earth, Moon and Planets*, 96, 149-163. [2] Cuzzi, J. N. et al., (1984) *IAU Colloquium 75: Planetary Rings*, 73-199. [3] Waite, J. H. et al. (2005) *Science*, 307, 1260-1262. [4] Hiller, J. K. et al., (2007) *Monthly Notices of the Royal Astronomical Society*, 377, 1588-1596.

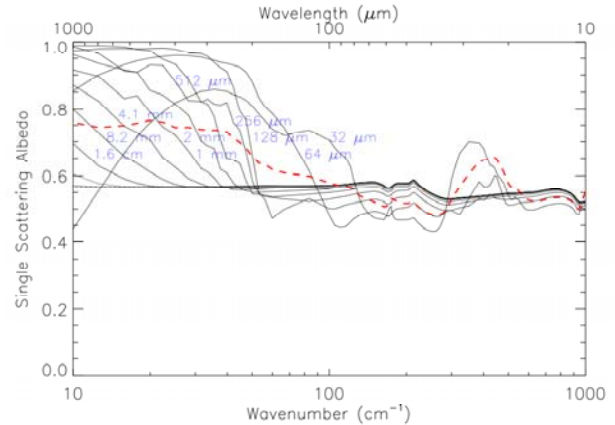


Figure 3: Single scattering albedo of water ice as a function of wavenumber as generated by a Mie scattering code. This plot illustrates the variation of single scattering albedo with particle size (from 32 microns to 1.6 cm). The dashed line displays the single scattering albedo from a weighted average of particle sizes designed to mimic the particle size distribution in Saturn's rings.