HEMISPHERICAL ASYMMETRIES IN SPECTRAL REDDENING ON THE CLASSICAL URANIAN SATELLITES: EVIDENCE OF INTRAPLANETARY DUST BOMBARDMENT. R. J. Cartwright[1] and J. P. Emery[2], [1]Department of Earth and Planetary Sciences, 1412 Circle Drive, University of Tennessee, Knoxville, TN 37996, rcartwri@vols.utk.edu.

Introduction: Ground-based observations of the classical Uranian satellites Ariel, Umbriel, Titania, and Oberon indicate that the surfaces of these moons are dominated by a mixture of H_2O ice and a dark, spectrally red, and presumably carbonaceous constituent [*e.g.*, 1-3]. Analysis of visible wavelength data (VIS, ~0.4 – 0.6 µm) gathered by the Imaging Science System (ISS) camera onboard the Voyager 2 spacecraft demonstrated that the leading hemispheres of these tidally-locked moons are spectrally redder than their trailing hemispheres [4-6]. Furthermore, the degree of spectral reddening on these satellites increases with distance from Uranus [4].

Subsequent dynamical modeling work [7-8] suggests that the hemispherical and planetocentric asymmetries in spectral reddening on these moons is most likey the result of infalling intraplentary dust from Uranus' irregular satellites, which are spectrally redder than the classical moons of Uranus [*e.g.*, 9]. The Voyager 2 encounter with the Uranian system occured near the peak of southern summer (subsolar point ~ 81°S) when the northern hemispheres of these moons were mostly shrouded in darkness and unobservable. It is therefore unclear whether the hemispherical and planetocentric trends in spectral reddening observed by Voyager 2 are global in extent, which would support the infalling intraplanetary dust hypothesis. Consequently, we are gathering new ground-based observations of these moons' now observable northern hemispheres (subsolar point ~35°N), thereby testing whether the observed asymmetries in spectral reddening are driven by irregular satellite dust bombardment.

Data and Methods: Using the MORIS camera co-mounted with the SpeX spectrograph [10] at NASA's Infrared Telescope Facility (IRTF), we are mapping the distribution of spectrally red material on the classical Uranian satellites as a function of satellite longitude (Table 1). To do this, we are measuring VIS spectral slopes across three Sloan Digitial Sky Survey (SDSS) filters with MORIS (g' r' i', spanning ~0.4 – 0.8 µm), as well as measuring the slopes of NIR spectra gathered by SpeX (~0.7 – 1.2 µm). We compare these northern hemisphere VIS and NIR spectral slopes to the ISS VIS colors of these moons' southern hemispheres. Reduction and analysis of the MORIS dataset are ongoing, and here, we focus on the outer two moons, Titania and Oberon.

Table 1: Summary of observations

	MORIS (VIS) ~0.4 - 0.8 *µm*		PRISM (NIR) ~0.7 - 1.2 *µm*	
Satellite	**Lead. Obser.**	**Trail. Obser.**	**Lead. Obser.**	**Trail. Obser.**
Miranda	3	3	0	0
Ariel	4	6	3	3
Umbriel	2	10	3	4
Titania	6	5	4	2
Oberon	5	7	5	2

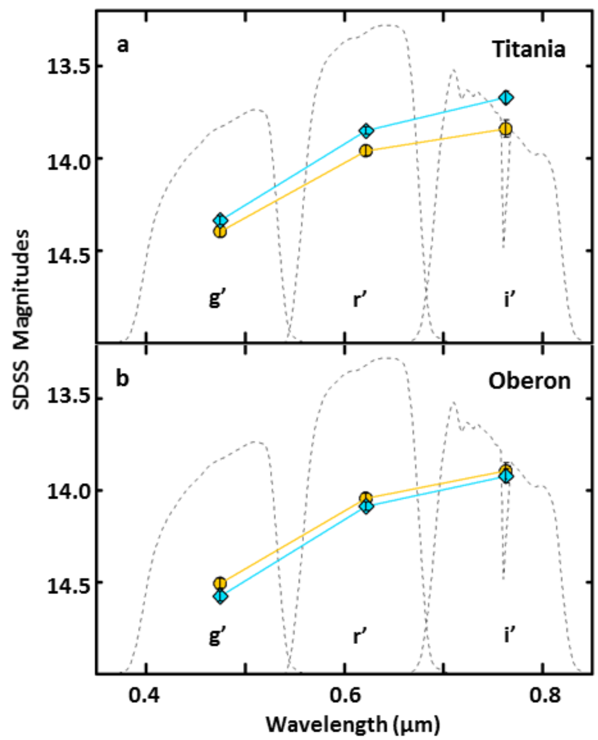

Figure 1: Mean leading (blue diamonds) and trailing (orange circles) SDSS magnitudes for (**a**) Titania and (**b**) Oberon, connected with same colored solid lines (2σ error bars). Spectral response curves (black dashed lines) shown to illustrate wavelength range of g', r', and i' SDSS filters (centered near 0.475, 0.622, and 0.763 µm, respectively).

Results: We present VIS magnitudes for Titania and Oberon in Figure 1 and mean NIR spectral slopes for all four satellites in Figure 2.

The leading hemisphere of Titania is significantly brighter (> 2σ) than its trailing hemisphere over VIS wavelengths. Conversely, there is no statistically significant distinction in brightness between the leading and trailing hemisphere of Oberon (Figure 1). Our preliminary analysis detects a small enhancement in reddening (< 2σ) on the leading hemispheres of these two moons compared to their trailing hemispheres (Table 2).

Over NIR wavelengths, the leading hemispheres of Umbriel, Titania, and Oberon are significantly redder than their trailing hemispheres (Figure 2), in particular for the outer two moons Titania and Oberon. Ratios between the mean spectral slopes for the leading and trailing hemisphere of each satellite (Figure 3b) indicate a steady (but non-significant) increase in reddening for Ariel, Umbriel, and Titania, and a significant (> 2σ) asymmetry in reddening for Oberon.

Discussion: The increase in spectral reddening with distance from Uranus, detected in the ISS dataset [4], is less prominent in our preliminary analysis of MORIS data for Titania and Oberon. Similarly, the non-significant difference in reddening between the leading and trailing hemsipheres of Titania and Oberon over VIS wavelength are inconsistent with previous analyses of the ISS dataset. Consequently, the southern and northern hemispheres of these two moons appear to display different trends in spectral reddening over VIS wavelengths.

In contrast, our analysis of NIR spectral slopes demonstrates clear differences in spectral reddening between the leading and trailing hemispheres of these moons (except for Ariel). We also note a steady increase in ratios between the leading/trailing NIR spectral slopes with distance from Uranus, similar to the leading/trailing VIS color ratios derived from the ISS dataset (Figure 3). Therefore, the southern and northern hemispheres of these two moons appear to display similar trends in reddening when comparing analyses of the ISS VIS dataset to SpeX NIR spectral slopes.

Future work will continue to investigate the southern/northern asymmetries detected in our preliminary analysis of MORIS data of Titania and Oberon, and determine whether these hemispherical asymmetries are present on Ariel and Umbriel as well. Furthermore, we will conduct spectral modeling [*e.g.*, 11] of the VIS and NIR spectral slopes to constrain the composition of the dark material on these moons.

Table 2: SDSS Color Indices

Satellite	Hemi.	g' - r'	Δ g' - r'	r' - i'	Δ r' - i'
Titania	Leading	0.486	0.015	0.180	0.020
	Trailing	0.437	0.021	0.119	0.028
Oberon	Leading	0.490	0.017	0.166	0.023
	Trailing	0.463	0.019	0.148	0.027

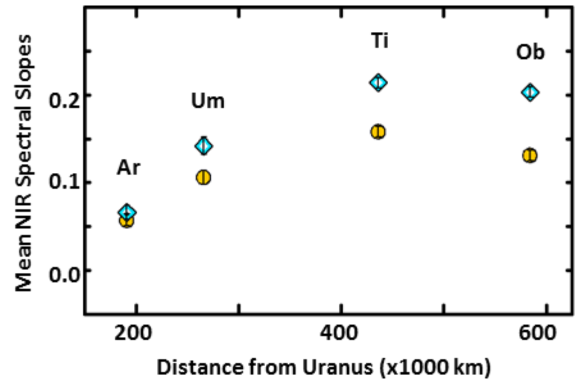

Figure 2: Mean leading (blue diamonds) and trailing (orange circles) NIR spectral slopes (2σ error bars). Ar = Ariel, Um = Umbriel, Ti = Titania, Ob = Oberon.

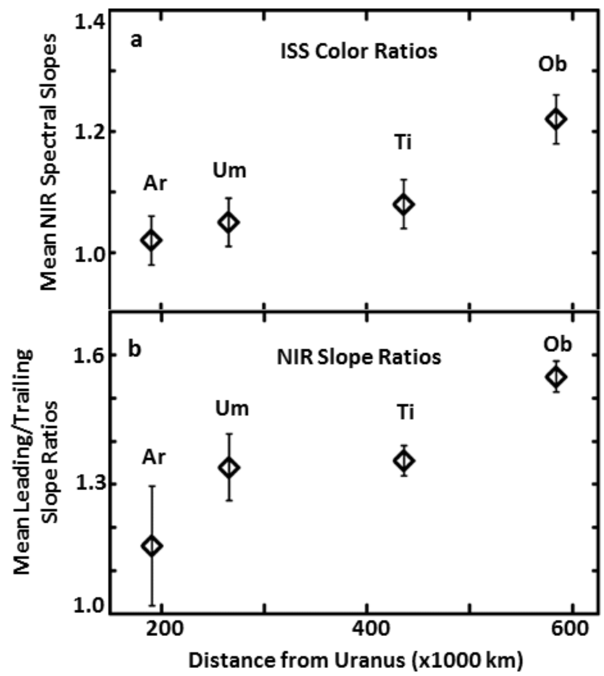

Figure 3: (**a**) Mean leading/trailing Voyager 2/ISS VIS color ratios for each moon (2σ error bars). (**b**) Mean leading/trailing IRTF/SpeX NIR slope ratios for each moon (2σ error bars). In both plots, Ar = Ariel, Um = Umbriel, Ti = Titania, Ob = Oberon.

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