BOLOMETRIC BOND ALBEDOS FOR SATURNIAN SATELLITES FROM CASSINI VIMS: LEADING AND TRAILING HEMISPHERES. K. M. Pitman[1], B. J. Buratti[2], J. A. Mosher[2]. [1]Planetary Science Institute, 1700 E. Fort Lowell Road, Suite 106, Tucson, AZ 85719 USA <pitman@psi.edu>, [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109 USA.

Introduction: One of the major strengths of the *Cassini* Visual and Mapping Infrared Spectrometer (VIMS, [1]) is its ability to acquire spectrophotometric information on the Saturnian system over a broader matrix than previously possible in terms of wavelength range ($\lambda \sim 0.34$-5.1 μm) and a vastly wider range of solar phase angles ($\equiv \alpha$). The most robust photometric properties for the Saturnian icy satellites to date can therefore be determined through use of the *Cassini* VIMS dataset with reference to *Voyager* and ground-based studies. We present values, derived from VIMS hyperspectral data, of four fundamental disk-integrated spectrophotometric properties (bolometric Bond albedo, solar phase curve, phase integral, and geometric albedo at 7 to 15 different wavelengths over the full VIMS range) for five mid-sized Saturnian icy satellites: Rhea, Dione, Tethys, Mimas, and Enceladus [2].

Methodology: The bolometric Bond albedo, A_{bolo}, is extremely important for determining the energy balance on the Saturnian moons, identifying the composition of geologic units, and finding volatile deposits. However, the geometric albedos for these moons, which factor into the determination of their A_{bolo} values, can be very difficult to ascertain unless one has reflected light measurements at extremely small solar phase angles. Fortunately, a large amount of VIMS data is now available at down to fractions of a degree in solar phase angle for several Saturnian moons and over double the solar phase angle coverage of the *Voyager* mission. We constructed phase curves utilizing the publicly available *Cassini* VIMS hyperspectral data collection covering the period 2004-2008, searching specifically for icy satellite observations with the widest possible coverage in solar phase angle on both leading and trailing hemispheres. This allows us to provide the major photometric quantities not only for each moon (e.g., Table 1) but also A_{bolo}, geometric albedo $p(\lambda)$, and phase integral $q(\lambda)$ of the leading and trailing hemispheres for each moon (e.g., Figs. 1-2, Table 2). The latter information is essential because leading/trailing dichotomies have been seen in Saturnian, Jovian, and Uranian icy satellites [3-6], yet leading and trailing photometric values, especially A_{bolo}, were previously only available for a few of the Saturnian icy satellites. Here we use the VIMS A_{bolo} values to determine percent brightness and first-order temperature differences between the two hemispheres.

Our phase curves also span a large number of representative absorption bands and continua relevant to H_2O ice (see [7] for a listing of visible to near-infrared H_2O ice bands). For comparison, preliminary VIMS solar phase curves using data from July 2004 to June 2005 were constructed at selected wavelengths (λ = 0.55, 2.23 μm; [8]). Our study adds the VIMS-IR bands (λ = 0.90, 1.00, 1.52, 1.80, 2.02, 2.23, 3.60 μm) for all moons. For Rhea and Dione, we also present disk-integrated photometric properties for some VIMS-VIS bands (λ = 0.35, 0.40, 0.51, 0.60, 0.70, 0.81, 0.90, 1.00 μm) and new rotational light curves at 7 near-infrared bands not previously available in ground-based or spacecraft studies [2].

We discuss our VIMS A_{bolo}, $p(\lambda)$, $q(\lambda)$, and solar phase curves in context with past ground-based and Voyager studies (e.g., [5, 9-17]), past VIMS spectral and phase curve studies [8, 18], and recent A_{bolo} results from the *Cassini* CIRS team [19].

Table 1: *Cassini* VIMS bolometric Bond albedos

Satellite	A_{bolo}	T_{eff} (K)¶
Rhea	0.48 ± 0.09	$76.5^{+3.1}_{-3.6}$
Dione	0.52 ± 0.08	$75.0^{+2.9}_{-3.3}$
Tethys	0.61 ± 0.09	$71.2^{+3.8}_{-4.5}$
Mimas	0.67 ± 0.10	$68.3^{+4.7}_{-5.9}$
Enceladus	0.85 ± 0.11	$56.1^{+8.3}_{-15.8}$

¶ $T_{eff} \equiv$ first-order estimate of effective temperature, calculated after [20]: $T_{eff} = [(1\text{-}A_{bolo})/(a^2)]^{1/4}$ 278K, with $a \equiv$ heliocentric distance of the icy satellite (AU).

Table 2: *Cassini* VIMS A_{bolo} by hemisphere

Satellite	Leading	Trailing
Rhea	0.55 ± 0.08	0.42 ± 0.10
Dione	0.63 ± 0.05	0.37 ± 0.08
Tethys	0.67 ± 0.09	0.52 ± 0.08
Mimas	0.65 ± 0.13	0.72 ± 0.10
Enceladus	0.77 ± 0.09	0.93 ± 0.11

A_{bolo} values such as those shown in Tables 1-2 may be used to give insight into which moons have internal heating sources and affect temperature estimates necessary for determining RADAR emissivity. These refined parameters can be used to construct future bolometric Bond albedo maps that will contribute to surface composition identification studies, as well as models of volatile transport and sublimation. Through such applications, these data will help to determine the physical properties of surface particles, how the E-ring affects the inner Saturnian moons, what is responsible for the dark albedo patterns seen on Tethys, and if these moons (e.g., Dione) are geologically active.

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References: [1] Brown R. H. et al. (2004) *Space Sci. Rev.*, *115*, 111-168. [2] Pitman K. M. et al. (2010) *Icarus*, in press. [3] Clark R. N. et al. (1984) *Icarus*, 58, 265–281. [4] Grundy W. M. et al. (1999) *Icarus*, 142, 536–549. [5] Cruikshank D. P. et al., (2005) *Icarus*, 175, 268–283. [6] Grundy W. M. et al. (2006) *Icarus*, 184, 543–555. [7] Clark R. N. (1981) *JGR*, 86, 3087–3096. [8] Filacchione G. et al. (2007) *Icarus*, 186, 259–290. [9] Hanel R. et al. (1982) *Science*, 215, 544-548. [10] Buratti B. J. and Veverka J. (1984) *Icarus*, 58, 254–264. [11] Verbiscer A. J. and Veverka, J. (1989) *Icarus*, 82, 336–353. [12] Noll K. S. et al. (1997) *Nature*, 388, 45–47. [13] Buratti B. J. et al. (1998) *Icarus*, 136, 223–231. [14] Momary T. W. et al. (2000) *Icarus*, 148, 397–406. [15] Verbiscer A. J. et al. (2005) *Icarus*, 173, 66–83. [16] Verbiscer A. et al. (2006) *Icarus*, 182, 211–223. [17] Kulyk I. (2008) *Planet. Space Sci.*, 56, 386–397. [18] Clark R. N. et al. (2008) *Icarus*, 193, 372–386. [19] Howett C. J. A. et al. (2009) *Icarus*, submitted. [20] Neff J. S. et al. (1985) *Icarus*, 62, 425–432.

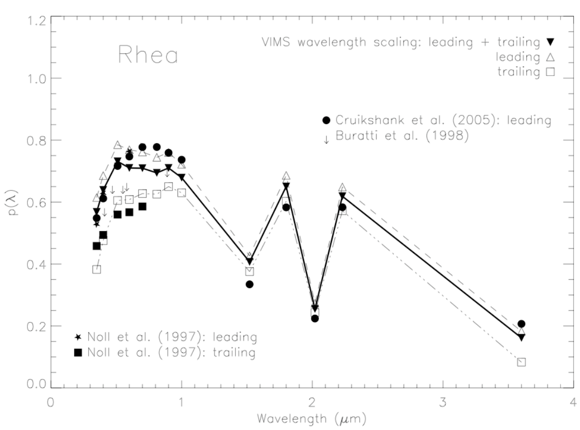

Fig 1: Geometric albedo p(λ) factors prominently into A_{bolo}. *Cassini* VIMS p(λ) values for Rhea [2] include behavior seen in VIMS phase curves and spectra. Comparison with past studies [5,12,13] is shown.

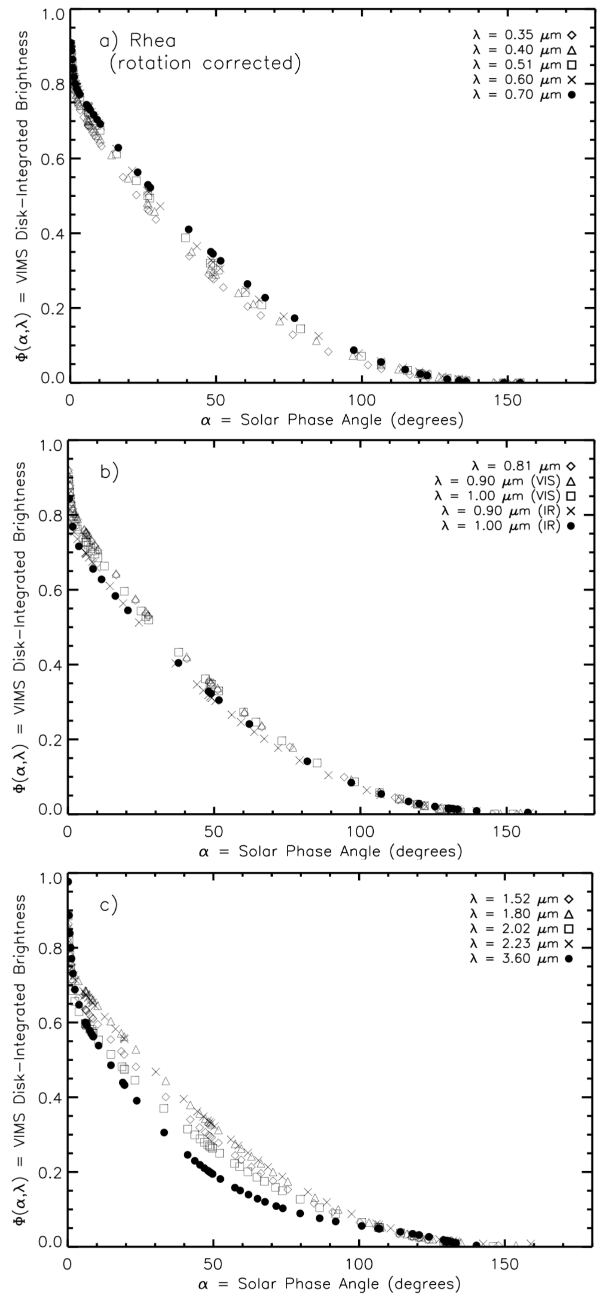

Fig 2a-c: Solar phase curves are required to determine phase integral q(λ), and ultimately A_{bolo}. Rotationally corrected *Cassini* VIMS light curves as a function of solar phase angle α for Rhea, with every 15th data point shown for clarity [2]. Of the Saturnian icy satellites, Rhea has the most robust phase curve, covering α = 0.05–160.96°, subspacecraft longitude = 4.13–357.97° W, and subspacecraft latitude = -75.70–80.11°.