IAPETUS, HYPERION AND PHOEBE: COMPARISONS FROM CASSINI UVIS. A. R. Hendrix[1] and C. J. Hansen[1], [1]Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Dr., MS 230-250, Pasadena, CA, 91109, hendrix@jpl.nasa.gov.

Introduction: We explore the albedo dichotomy of Iapetus as measured at far-UV wavelengths (1100-1900 Å), and extend the comparisons between Iapetus and candidate dark material sources, including Phoebe and Hyperion, to shorter wavelengths.

Iapetus' Albedo Dichotomy: Iapetus has intrigued planetary scientists for centuries, primarily due to its striking hemispheric albedo dichotomy. The leading hemisphere (centered on 90°W) is very dark, reflecting just ~4% of the visible light that hits it, while the trailing hemisphere (centered on 270°W), is relatively quite bright and has a visible albedo of ~60%. The exact composition of the dark material is not known; the presence of a deep 3.0 μm absorption feature has led to comparisons with C-type asteroids [1] and primitive meteorite-type material [2] while its red VNIR spectrum has been compared with organic material [3]. Water ice is present in very small amounts in the dark material; spectral mixing models (using both disk-integrated ground-based and disk-resolved Cassini data) show that the dark terrain contains ~5% water ice [4][5]; Bell *et al.*, 1985 note that the water ice features in their spectrum are due to the bright polar region material in the frame and attempt to remove them using a linear mixing model.

It is not known whether the leading hemisphere dark terrain has been created through exogenic processes [6] or whether geologic activity within Iapetus emplaced dark material from within [7][8]. Voyager images of dark-floored craters within the bright terrain pointed to an endogenic source; they also suggested that the light-dark boundary is too irregular to be consistent with infalling dust [7][8]. However, albedo patterns observed by Cassini cameras in late 2004 suggest external emplacement of material (e.g., dark material on ram-facing crater walls at high latitudes). The initial theory of an exogenically-created dark pattern [6] suggested that pre-existing dark material was uncovered by meteoritic bombardment; this idea was extrapolated upon [9]. Later theories [10] suggested that the dark material is exogenically emplaced on Iapetus' leading hemisphere as material is lost from the moon Phoebe [11]. Retrograde Phoebe dust from 215 R_S would travel inward and impact the leading hemisphere of Iapetus, orbiting at 59 R_S. However, Phoebe is spectrally gray at visible wavelengths, while the Iapetus dark material is reddish [3][12]. If the material does come from Phoebe, then some sort of chemistry or impact volatilization must occur to change the color and darken the material [3] [13]. Another possibility is that the exogenic source of the dark material is either Hyperion [14] or Titan [4]. Both Hyperion and Titan tholin material are spectrally reddish, though not as dark as Iapetus. Another possibility is that both Hyperion and Iapetus' leading hemisphere are impacted by dark, reddish dust from retrograde satellites exterior to Phoebe [15]. Ground-based RADAR observations at 13 cm [16] and Cassini RADAR data at 2.2 cm [17] indicate that the dark terrain must be quite thin (one to several decimeters); an ammonia-water ice mixture may be present below several decimeters of the surface on both the leading and trailing hemispheres of Iapetus. The RADAR results are consistent with the density of 1.2 g/cm^3, from which it can be inferred that the moon is composed primarily of water ice. Because large craters within the dark terrain appear to be evenly colored with the dark material (no craters appear to break up the dark material, exposing bright underlying terrain), this suggests the emplacement of the dark material is relatively new or ongoing. The RADAR results appear to rule out the theories of a thick dark material layer [9] [14].

Observations: The observations reported here were obtained by the Cassini Ultraviolet Imaging Spectrograph (UVIS) [18]. The UVIS uses two-dimensional CODACON detectors to provide simultaneous spectral and one-dimensional spatial images. The far-UV channel of UVIS covers the 1115-1912 Å range. The detector format is 1024 spectral pixels by 64 spatial pixels. Each spectral pixel is 0.25 mrad and each spatial pixel is 1 mrad projected on the sky. The high-resolution slit has a spectral resolution of 2.75 Å and pixel width of 0.75 mrad. Iapetus measurements were made from a closest-approach distance of 123,000 km on December 31, 2004, of both the leading hemisphere dark terrain and the bright terrain in the north pole region. During the Iapetus flyby, Cassini flew over the leading, dark hemisphere which was illuminated at ~ 55° phase. The groundtrack approached the northern hemisphere and went onto the unilluminated trailing hemisphere. The Iapetus observations used the low-resolution slit with a spectral resolution of 4.8 Å and pixel width of 1.5 mrad. The Phoebe and Hyperion observations used the high-resolution slit.

Results: *Spectral Models.* We use intimate mixtures models in an attempt to simulate the measured reflectance spectra and understand the surface compo-

sitions of these bodies. We can get a good spectral match to the Iapetus bright north polar terrain using an intimate mixture of 75% H_2O ice and 25% Triton tholin, consistent with Cassini VIMS results [20]. The average dark terrain can be fit with an intimate mixture of 5% H_2O ice, 55% poly-HCN and 40% Triton tholin, again consistent with VIMS results [20]. We also detect color variations across the leading hemisphere and discuss spectral models of compositional variation within the dark terrain.

Comparisons with Phoebe and Hyperion. As previously discussed, the possibility of Iapetus' dark material being related to Phoebe and/or Hyperion has been studied by many researchers at visible and near-IR wavelengths; we now extend that comparison to FUV wavelengths. An average Phoebe spectrum is shown in Fig. 1, compared with spectra from Iapetus's bright and dark material. These spectra were taken at the same solar phase angle; no scaling of spectra has been performed. We find that Phoebe's FUV spectrum is very similar to that of Iapetus's bright material – not of Iapetus's dark material. It is thus very unlikely that pure Phoebe material is what darkens Iapetus' leading hemisphere – unless all of the water ice in Phoebe's material is lost in the impact process.

The visible spectrum of Iapetus' bright trailing hemisphere is similar spectrally to Phoebe's spectrum [19]. Phoebe's visible wavelength geometric albedo is ~0.06 [21]. while the geometric albedo of Iapetus' bright trailing hemisphere is ~0.60. However, since we find that at FUV wavelengths Phoebe and Iapetus's bright terrain are spectrally similar in both color and magnitude (at 90° phase), this means that either 1) a spectrally active material is present in Iapetus' bright terrain that darkens the surface between the visible and the FUV, or that 2) the phase functions of the two bodies are very different, due to differences in the scattering properties of the surfaces. Because HST data in the near-UV shows that the Iapetus trailing hemisphere has a relatively flat spectrum [22], this suggests structural differences within the regoliths of the two bodies.

Comparisons can also be made with Hyperion. Hyperion is spectrally red at visible wavelengths, similar to D-type asteroids, and has been compared with organic material. We find that at FUV wavelengths, Hyperion is not spectrally redder than the Iapetus dark material, but does appear to have more water ice. Even when we attempt to isolate a spectrum of Hyperion dark material, the Hyperion dark material still appears to have more water ice than the Iapetus dark material – no other spectral variations are apparent.

References: [1] Lebofsky L. A. et al. (1982) *Icarus, 49,* 382-386. [2] Bell J. F. et al. (1984) *Icarus, 61,* 192-207. [3] Cruikshank D. P. et al. (1983), *Icarus, 53,* 90-104. [4] Owen T. C. et al. (2001) *Icarus, 149,* 160-172. [5] Buratti B. J. et al. (2005) *Icarus, 175,* 490-495. [6] Cook A. F. and Franklin F. (1970) *Icarus, 13,* 282-291. [7] Smith B. A. et al. (1981) *Science, 212,* 163-191. [8] Smith B. A. et al. (1982) *Science, 215,* 504-537. [9] Wilson P. D. and C. Sagan (1996) *Icarus, 122,* 92-106. [10] Soter, S. (1974) *IAU Colloq.* [11] Burns J. A. et al. (1979) *Icarus, 40,* 1-48. [12] Squyres S. W. et al. (1984) *Icarus, 59,* 426-435. [13] Buratti B. J. and Mosher J. A. (1995) *Icarus, 115,* 219-227. [14] Matthews R. A. J. (1992) *Q. J. R. Astr. Soc., 33,* 253-358. [15] Buratti B. J. et al. (2002) *Icarus, 155,* 375-381. [16] Black G. J. et al. (2004) *Science, 304,* 553. [17] Ostro S. J. et al. (2006) *Icarus, 183,* 479-490. [18] Esposito L. W. et al. (2004) *Space Sci. Rev., 115,* 299-361. [19] Jarvis K. S. et al. (2000) *Icarus, 146,* 125-132. [20] Buratti B. J. et al. (2005) *Ap. J., 622,* L149-L152. [21] Simonelli D. P. et al. (1999) *Icarus, 138,* 249-258. [22] Noll K. S. et al. (1997) *Nature, 388,* 45-47.

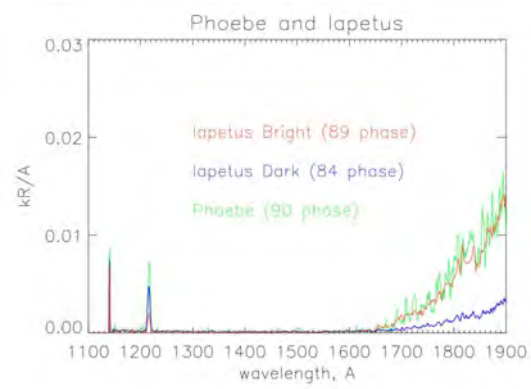

Fig. 1. Comparison between spectra of Phoebe and Iapetus bright and dark terrains. At similar phase angles, Phoebe provides a close match to the bright material on Iapetus, not the dark material.