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THE NEAR-INFRARED REFLECTIVITY OF THE DARK AND LIGHT FACES OF IAPETUS

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ABSTRACT

Low resolution spectra have been obtained from 2.0–2.5 μm of the dark and light sides of Iapetus. The spectrum of the light side confirms the presence of ice as observed by Fink *et al*. The spectrum of the dark side is flat with wavelength. This is taken as evidence that the surface of the dark side is an asteroidlike material.

I. INTRODUCTION

Iapetus has some of the most peculiar photometric properties of all the planetary satellites of the solar system. The observed apparent visual magnitude of this planet varies by more than two magnitudes as a function of orbital phase. Iapetus is brightest when the trailing hemisphere faces the Earth (western elongation) and faintest when leading hemisphere faces the Earth (eastern elongation). Near-infrared spectroscopy (Fink *et al.* 1976) has shown from the reflectivity spectrum that the bright side of Iapetus is nearly completely covered with water ice. We present here observations that confirm the presence of ice on the light side and show it is absent on the dark hemisphere of Iapetus.

II. OBSERVATIONS

The observations reported here consist of spectrophotometry from 2.0–2.5 μm obtained at nearly eastern and western elongations of Iapetus using an InSb detector and liquid nitrogen cooled circular variable interference filter spectrometers on the 2.5 and 1.5 m telescopes at Mt. Wilson.

Although the observations were not obtained at exactly maximum elongations, the contribution from the mostly hidden hemisphere was quite small. About 3% of the observed area of Iapetus was dark on 26 January 1979 (UT), the time of observation of the bright surface; less than 1% and ~2% of the observed area was light at the time of the 5 March 1979 (UT) and 7 March 1979 (UT) observations. The sky conditions on the former date were not photometric and the observations were, in fact, stopped by clouds. The journal of observations is given in Table I and the spectra of Iapetus are shown in Fig. 1. The spectra were corrected for instrumental response and atmospheric transmission by observing the standard stars ρ Vir (A0V) and ρ Leo (B1Ib). The energy distributions of these stars were assumed to follow a 9700 K blackbody spectrum and the flux densities at 2.2 μm were taken as 5.1 and 7.2 × 10^{-12} W m^{-2} μm^{-1}.

III. DISCUSSION

The observed flux densities of Fig. 1 were converted into geometric albedos as a function of wavelength by finding the ratio of the observed intensity to that of a perfect diffuse reflector at the distance of Iapetus. The distances from Iapetus to the Earth and the Sun were taken from the American Ephemeris and Nautical Almanac (1979), the radius of Iapetus was assumed to be 724 km (Veverka *et al.* 1978) and the solar spectrum was taken from Arvesen, Griffin, and Pearson (1969). The parameters of the calculation are shown in Table II and the results are displayed in Fig. 2.

The albedo of the bright side of Iapetus shows a strong 2.24 μm peak which is the characteristic spectral signature of water ice (Fig. 2); this result is consistent with

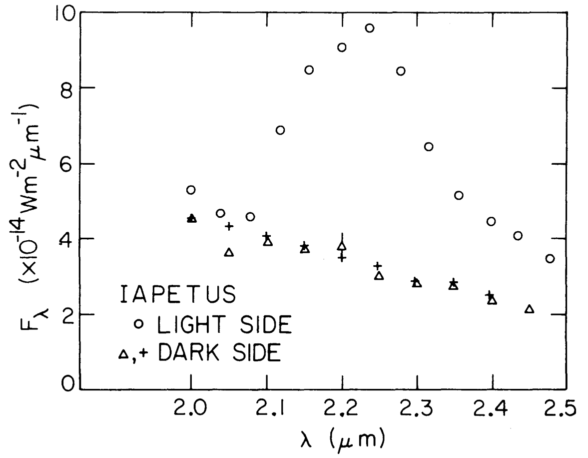

FIG. 1. The flux density of the light and dark faces of Iapetus as measured on 26 January 1979 (circles), 5 March 1979 (crosses), and 7 March 1979 (triangles). Except where shown explicitly the relative statistical uncertainties are less than 10%.

[a] Operated jointly by the Carnegie Institution of Washington and the California Institute of Technology.

TABLE I. Journal of observations.

Observation date (UT)	26.4 Jan 1979	5.3 Mar 1979		7.3 Mar 1979
Face of Iapetus	Light		Dark	
Iapetus orbital phase (°)	284	93		102
Phase of elongation (°)	270(W)		90(E)	
Solar phase angle (°)	3.7		0.5	
Telescope aperture (m)	2.5		1.5	
Wavelength λ (μm)	2.0–2.47		2.0–2.45	
Resolution Δλ/λ	0.015		0.05	

the previous observations of Fink *et al.* (1976). The dark side of Iapetus shows a much darker, virtually gray albedo over the 2.0–2.5 μm region, the weak suggestion of a peak in the albedo at ~2.25 μm on 7 March 1979 (UT) may be due to contamination from the flux of the lighted side. The dark side of Iapetus is thus substantially different from the light side in the 2.0–2.5 μm wavelength region; this difference is in contrast to the optical behavior of Iapetus, where the *UBV* color of the satellite changes very little over the orbital period (Millis 1977).

Less than ~5% of the dark side can be covered with ice having reflectivity properties similar to those of the bright side of Iapetus. This limit on the amount of ice visible on the dark side eliminates one possible explanation of the variability of the visual light with orbital phase: The dark side cannot have completely (or nearly so) black material covering 4/5 of the surface and ice covering the remaining 1/5 of the surface.

The geometric albedo of the dark side of Iapetus at 2.24 μm is 0.12 ± 0.02, and is quite flat as a function of wavelength between 2.0 and 2.5 μm. The flat behavior of the albedo in the near infrared is typical of the reflectances of many asteroids as determined from broadband 1.25, 1.65, and 2.2 μm observations (Veeder, Matson, and Smith 1978). The visual geometric albedo of the dark side in 1971–1973 was $p_v = 0.11 \pm ^{0.04}_{0.03}$ (Morrison *et al.* 1975; Veverka *et al.* 1978). Recent observations by Millis (1977) show that the amplitude of the visual light curve is increasing with time in the sense that the visual albedo of the dark side decreased by 0.15 mag from 1971 to 1975. Thus the ratio of 2.2 to visual albedo, $p_{2.2}/p_v$, is on the order of 1.1–1.4. These observations are in general agreement with the broadband observations of Veeder and Matson (1979). Such relative reflectances are in the range found by Veeder *et al.* to hold for C and S type asteroids although the visual albedos for C type asteroids are in the range $p_v \sim 0.05$. Possible changes in the albedo as a result of the small solar phase angle have not been considered but are on the order of 10%–20% in the visual (Millis 1977). The flat behavior in the reflectivity appears to be inconsistent with lunar-type dust material covering the dark side of Iapetus, since the reflectivity of lunar material rises sharply from visual to infrared wavelengths (McCord and Johnson 1970). The data are thus consistent with the model of the surface of the leading face of Iapetus being asteroidlike dark material.

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TABLE II.

Date (UT)	1979 Jan 26.4	1979 Mar 5/7
Iapetus–Earth distance (km)	1.27×10^9	1.25×10^9
Iapetus–Sun distance (km)	1.39×10^9	1.39×10^9
Iapetus solid angle (sterad)	1.02×10^{-12}	1.06×10^{-12}
2.24 μm flux density (W m^{-2} μm^{-1})	9.6×10^{-14}	3.3×10^{-14}
2.24 μm specific intensity (W m^{-2} μm^{-1} $sterad^{-1}$)	9.4×10^{-2}	3.1×10^{-2}
2.24 μm geometric albedo	0.38	0.12

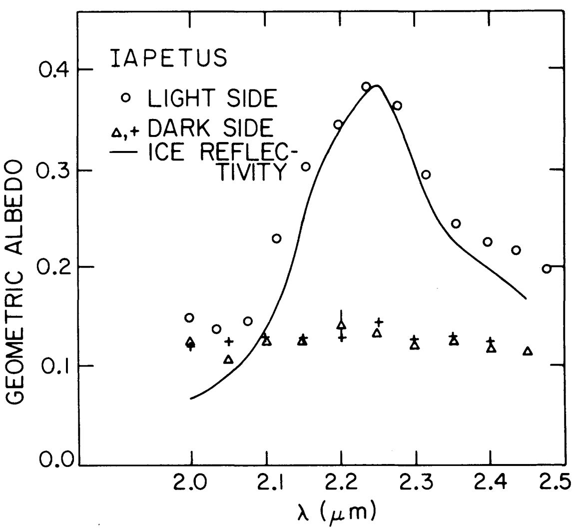

FIG. 2. The geometric albedos as calculated from the data of Fig. 1 and the parameters shown in Table II. Symbols are the same as Fig. 1.

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