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Combined albedo spectrum of Phobos in UV and Visible with SPICAM and OMEGA on Mars Express

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Abstract

Mars Express made several encounters with Phobos for the last 6 years. Observations with SPICAM and OMEGA on board Mars Express cover the range from UV (190-310 nm) to visible and near IR up to 5 µm. In the following we consider only the visible channel of OMEGA and the UV channel of SPICAM. In the UV channel, there is a dip in the geometrical albedo spectrum centered at 220 nm, similar to the one observed in the interstellar extinction, interpreted of PAH origin. The combined UV/VIS SPICAM/OMEGA spectrum exhibits another strong dip centered at 350 nm. It could tentatively be attributed to the presence of ilmenite.

1. Introduction

The albedo of a small body surface may serve two purposes. One is to compute the amount of solar radiation absorbed by the body, in order to derive thermal properties of the surface and subsurface. The other is to analyze its spectrum, in order to determine the composition of its surface and possibly to detect volatiles or non-volatiles deposits, by comparison with laboratory measurements of pure samples.

2. Geometric albedo seen in the UV.

The geometric albedo of an astronomical body is the ratio of its actual brightness at zero phase angle to that of an idealized flat, fully reflecting, diffusely scattering (lambertian) disk with the same cross-section S: GA=π B/F. In the following we extend this definition to non-zero phase angles.
For the determination of the geometrical albedo, observations made from a larger distance are preferred for SPICAM, because otherwise there is a small contribution of stray light from the disc of Phobos outside the FOV. Figure 1 represents the UV geometric albedo obtained at orbit 748 of Mars Express at a phase angle of 22° and 1248 km distance. Phobos is extremely dark in the UV, with an albedo of only 2%. The sharp increase at 310 nm is most likely an artifact due to the low sensitivity of the detector at this end of the spectrum. There is a broad absorption at 220 nm reminiscent of interstellar extinction, suggested to be due to an organic material, PAH: Polycyclic Aromatic Hydrogen C_{24} H_x, with X<4 by Duley and Lazarev (2004) [1].

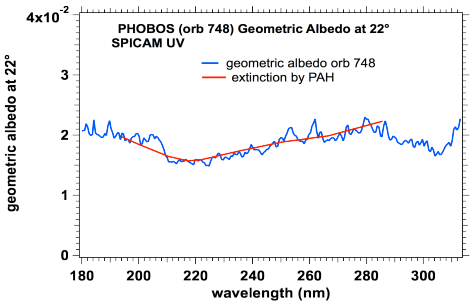

Figure 1 Geometric albedo of Phobos (phase angle 22°) in the 180-220 nm range obstained by SPICAM at orbit 748. The red curve is a curve calculated from observed interstellar extinction. The longward increase (>305 nm) is probably spurious, where the sensitivity is low.

3. Combined spectrum SPICAM/ OMEGA.

During a close encounter (158 km) at orbit 756, both SPICAM and OMEGA made resolved measurements of the radiance factor Rad (classical I/F): Rad= π B(λ)/Fs (λ), where B(λ) is the brightness and Fs (λ) is the solar flux at Phobos.
Special care must be taken to combine measurements of the two spectrometers which have different FOV, to ensure that the solar incidence angle, the phase angle and the emission angle are identical in the two wavelength domains.

Figure 2 shows the geometry, in which the image of Phobos is recorded in a push-broom mode (time goes from left to right). The red rectangle indicates the OMEGA area scanned in a whisk-broom mode, while the blue rectangle is the area recorded by SPICAM UV in push-broom, with 5 FOV in parallel at each second (yellow rectangles). The radiance factor was averaged over the whole observation (inside the blue rectangle) for the two instruments, in such a way that the radiance factors in the two wavelength domains are directly comparable. Figure 3 shows the combined spectrum.

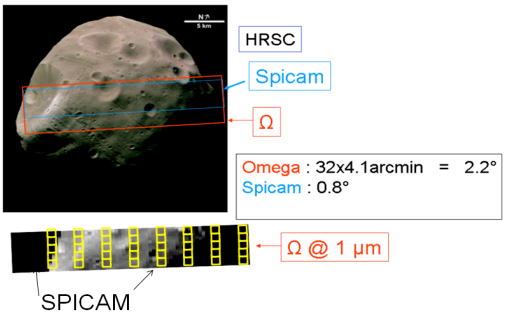

Figure 2. Geometry of close approach at orbit 756. The various FOVs of SPICAM are represented by yellow squares.

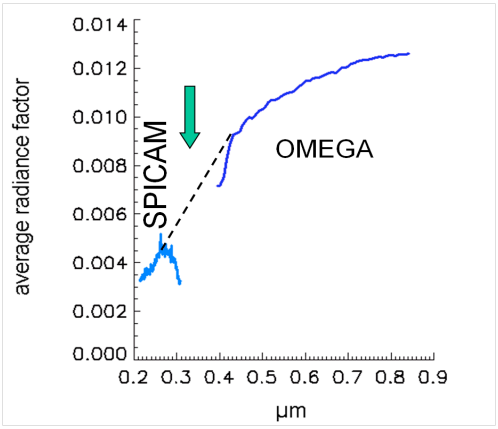

Figure 3. The combined spectrum of Radiance Factor from SPICAM and OMEGA suggests the presence of a deep absorption feature (green arrow).

In the UV the value of the radiance factor is ~ 0.005, 4 times less than the geometric albedo at 22° phase angle. This is because the area scanned during orbit 756 is not far the terminator, and the Solar Incidence angle is large. There is a data gap between 310 nm (end of SPICAM) and 390 nm (short end of OMEGA). Still, the combination strongly suggests that there is an absorption feature centered at ~ 350 nm, with a width of 100 nm and a depth up to 50 %, which was not reported before. A non-exhaustive comparison with some samples of a lab data base [2], show only a hint of resemblance with some type of ilmenites.

4. Conclusions.

We found two spectral dips in the reflectance of Phobos. One is found in SPICAM data at 220 nm, suggesting that Phobos may be covered with some organic material like PAH. The other band is detected at 350 nm by combining OMEGA and SPICAM. Both spectral features are in the UV. There is no other confirmed spectral feature in the whole Visible IR (up to 3 µm) [3], [4], stressing the importance of these two UV spectral features warranting more studies and observations.

Acknowledgements

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