Deimos photometric properties from Mars Express HRSC/SRC observations

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For more than 21 years, the Mars Express mission (MEx) has been orbiting the Martian system, acquiring data on Mars' surface and atmosphere, as well as on its two moons, Phobos and Deimos. The origins of the Martian moons remain a matter of debate. Deimos is much less well known than Phobos. It is the smallest of the two moons and orbits Mars at a much greater distance than Phobos, at more than 23,000 km. Previous photometric analyses [1] show that the surface of Deimos is smoother and more homogeneous than that of Phobos, but with overall similar photometric properties.

We analyzed images of Deimos taken with both the High Resolution Stereo Camera (HRSC) and the Super Resolution Channel (SRC). HRSC is a nine-channel stereo scanner including five panchromatic and four color filters (blue, green, red, and infrared), while the SRC is a framing camera with one panchromatic filter centered at 650 nm and covering from 400 to 900 nm [2,3]. The HRSC Deimos dataset is relatively limited with only 19 images available in each filter, acquired between January 2018 and January 2025, with a spatial resolution ranging from 390 m/px to 800 m/px. In contrast, the SRC dataset of Deimos contains more than 3000 images covering more than 20 years of observations, from October 2004 to December 2024. The spatial resolution varies from 85 m/px to 300 m/px, while the phase angle ranges from 0.06 to 105°. For the very first time, we have absolutely calibrated the SRC using images of stars and Jupiter. We performed both disk-integrated and disk-resolved photometry. From the retrieved phase curve, we applied the Hapke IMSA [4] model to characterize the texture of the surface.

The results obtained in the four HRSC color filters indicate that Deimos is photometrically similar to Phobos, while slightly brighter in the blue and green filters (Fig.1). Looking at the images, a bright region –corresponding to the equatorial ridge –is evident (Fig. 2). Except for this feature, the surface of Deimos appears to be homogeneous. In particular, the ridge is about 35% brighter than the average surface of Deimos. It is also notable that the craters (e.g., Voltaire (22°N; 3.5°E) and Swift (12.5°N; 358°E) craters) appear to exhibit no discernible increase in reflectance compared to the average surface. This is in contrast to Phobos, where the crater rims are significantly brighter (up to 50%) than the average surface. This suggests that the craters on Deimos are likely relatively old.

The preliminary derivation of the Hapke parameters shows also very similar values compared to Phobos: $\omega = 0.078 +/- 0.003$, $g = - 0.25 +/ 0.01$, $B_{sh,0} = 2.15 +/- 0.08$, $h_{sh} = 0.054 +/- 0.001$, and $\theta = 22 +/- 1°$.

This work is the first extended study of the photometric properties of Deimos, in particular covering the opposition effect. The results are of significant interest for JAXA’ s Martian Moon eXploration (MMX) mission [6], which will be launch in 2026 and return samples from Phobos to determinine the origin of the Martian moons, as well as analyzing the data obtained during the flyby of Deimos by the Hera spacecraft, which will take place in March 2025.

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References: [1] Thomas et al. (1996), Icarus, 123, 536-556 [2] Jaumann et al., PSS, 55, 928-952 [3] Oberst et al. PSS, 56, 473-491 [4] Hapke (2012), Cambridge University Press [5] Fornasier et al. (2024), A&A , 686, A203 [6] Kuramoto et al. (2022), EPS, 74, 1, 12

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Fig. 1

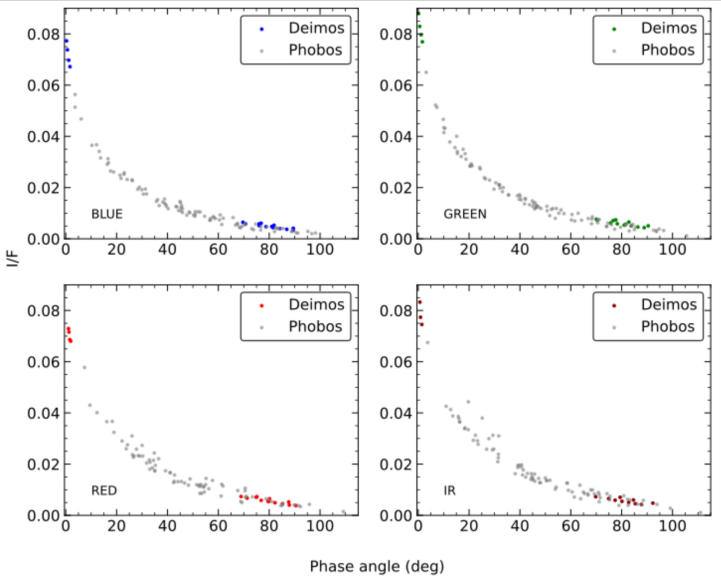

Fig. 2