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Opposition effect of Phobos from Mars Express HRSC observations

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The origin of the two Martian moons - Phobos and Deimos, remains enigmatic. Asteroid capture and accretion of the Martian debris disk (formed during planet formation or later induced by impact) are currently the two hypothesized explanations (Burns 1972, Craddock 2011). The upcoming JAXA mission, Martian Moon Explorer (MMX), aims to definitively resolve this debate by directly acquiring samples from Phobos for analysis on Earth.

The observations of Phobos from the High-Resolution Stereo Camera (HRSC) onboard the Mars Express spacecraft can provide valuable information to support sample return mission planning. Surface physical properties, such as porosity and particle size, are critical for planning sample collection strategies and selecting suitable sampling locations. Earlier photometric studies have primarily focused only on integrated photometry or lacked sufficient spatial resolution (Simonelli et al. 1998, Pajola et al. 2012). Consequently, these studies offer limited constraints on surface physical parameters. The recent work of Fornasier et al. (2024) using the HRSC observations has found the opposition surge amplitude to be considerably lower than the earlier works based on the Viking mission observations (Simonelli et al. 1998). The difference in opposition surge parameters for different albedo regions has also been reported.

Our work aims to establish disk-resolved empirically derived opposition surge parameters for various HRSC filters. This will serve as a verification for some of the parameters derived by Fornasier et al. (2024) through empirical photometric models. The disk-resolved parameters will also enable more accurate estimations of regolith porosity and particle size, facilitating safe and efficient rover operations on the Phobos surface. Additionally, we will analyze panchromatic filter images to generate high-resolution maps of scattering parameters. These maps will serve a dual purpose: facilitating the selection of optimal sampling locations while also improving our understanding of Phobos' global geological features. Finally, a comparative analysis of the derived regolith properties with those of other Solar System bodies is planned to glean deeper insights into Phobos' origin. This work aims to support the JAXA MMX mission and contribute to a more comprehensive understanding of the Martian moon's origin and evolution.

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