Shape modeling strategy for MMX

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The JAXA-led Martian Moons Exploration (MMX) mission is scheduled for launch in 2024 to reveal the origin of two moons: Phobos and Deimos. MMX spacecraft will be inserted into quasi-satellite orbit (QSO) to observe Phobos, which will contribute to improving our geodetic knowledge such as shape, rotation, and gravity field of the satellite. Although it is not straightforward to relate internal properties to the origin, these geodetic observations are precious to infer internal structure (Le Maistre et al., 2019). A shape model, one of the geodetic products, is also of importance for interpreting remote sensing observation as well as selecting landing site to sample surface materials. This paper describes current strategy for MMX shape modeling.

In contrast to the current situation of limited number of Phobos images with inhomogeneous spatial resolution (Karachevtseva et al., 2014), MMX will provide number of images with more homogenous quality and resolution. The initial base shape model will be constructed from telescopic camera images to be acquired during terminal rendezvous phase from a few thousand kilometers distance, with Phobos being framed within the field of view of the camera. More detailed topography will be reconstructed from images taken from QSO with higher spatial resolution. The size of QSO are roughly divided into three levels, i.e., high (QSO-H, 100x200 km), mid (QSO-M, 50x100 km), and low (QSO-L < 50 km). For QSO-H configuration, the apparent orbital period in Phobos-centered inertial frame is about 35 days and we will be able to observe dayside of Phobos for about two weeks. In order to provide a shape model in early stage of investigation, we will make use of the first QSO-H period with spatial resolution better than 2 m and with scan observation covering at least ±30 deg latitudinal band.

Stereophotoclinometry (SPC), the same technique as used for Hayabusa2 (Watanabe et al., 2019), is also one of the candidates to be applied to MMX. In order to make the shape modeling effective, based on a planned QSO-H trajectory, we investigated the optimal timings of observations with illumination conditions that are preferable for SPC. The LIDAR data, that will be available at least around regions with the lowest altitude, give the scale of the shape model. Preliminary study shows that the necessary observations will be completed within the first dayside observation chance, even if we consider realistic bus operation time during which Phobos cannot be observed, when certain speed of spacecraft attitude scan is realized.

References

Karachevtseva et al., Planet.SpaceSci., 102, 74-85, 2014; Le Maistre et al., Icarus, 321, 272-290, 2019; Watanabe et al., Science, 364, 268-272, 2019.

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