Phobos Spectral Investigation with the MIRS Spectrometer on board the Martian Moon eXploration (MMX) Mission. A. Doressoundiram [1], M.A. Barucci [1], J.-M. Reess [1], P. Bernardi [1], S. Fornasier [1], M. Le Du [2], E. Sawyer [2], V. Piou[2], T. Iwata [3], H. Nakagawa [4], T. Nakamura [4] and MIRS team, [1] LESIA-Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Université Paris Cité, 92195 Meudon Principal Cedex, France, alain.doressoundiram@obspm.fr; [2] CNES, 18 Av. Edouard Belin, 31400 Toulouse, France ; [3] ISAS, JAXA, Kanagawa, 252-5210, Japan ; [4] Tohoku University, 6-3 Aramaki-aza-Aoba, Aoba-ku, Sendai, Miyagi, 980-8578, Japan.

Introduction: The origin of Phobos and Deimos, the two natural satellites of Mars is still debated. Two main hypotheses are currently considered for their formation. The first, long favored but now questioned, would be a capture by the gravitational influence of Mars, of asteroids from the main belt [1]. The second is the accretion in orbit around Mars of residues from a major collision of Mars and a protoplanet several billion years ago [2].

It is in this context that JAXA's Martian Moon Exploration (MMX) mission [3] will be launched in 2024 to go study these satellites and in particular Phobos, with sample collection and return to Earth. Among the MMX instrumental suite, the MIRS (MMX Infrared Spectrometer) instrument developed by a consortium of French laboratories, led by LESIA-Paris Observatory, in partnership with CNES and in collaboration with JAXA, will be at the heart of the strategy for observing and characterizing the surface of Phobos, as well as support the choice of sampling sites [4].

MIRS is a spectro-imager operating from 0.9 to 3.6 µm with a spectral resolution of at least 20 nm and a spatial resolution on the order of meters for the study of sampling sites on the surface of Phobos. MIRS will provide in-depth spectral characterization of the surfaces of Phobos and Deimos, mapping their mineralogical compositions and searching for the presence of organic compounds. This task will be of primary importance for the choice of sites for MMX sampling of the surface of Phobos. MIRS will also study the Martian atmosphere, focusing in particular on the spatial and temporal variations of water vapor, dust, and clouds [4].

MIRS instrument: MIRS is an imaging spectrometer that uses the push-broom acquisition principle. The instrument is designed to fully accomplish MMX's scientific and measurement objectives. Then instrumental characteristics are:

- Spectral range: 0.9 – 3.6 µm
- Spectral resolution (sampled) < 20 (+10%) nm
- Spectral sampling: 10 (+10%) nm
- IFOV: ≤ 0.41 mrad, goal: 0.35 mrad
- FOV: ≥ ±1.65°
- SNR: ≥ 100 in [2.7 - 3.2] µm in less than 2 sec integration, for 30° solar incidence, at 1.5 au, with Lambertian albedo at 30° phase angle

Observations of Phobos: MMX will orbit Phobos on quasi-satellite orbits (QSOs) from Hight, Medium and Low altitude. Then MIRS will be able to map the surface composition at different spatial resolutions. The global mapping of Phobos will be achieved at spatial resolution of about 20 m.

The spectral coverage of MIRS, from 0.9 to 3.6 µm will permit to investigate all present bands to constrain the mineralogy, species abundances and composition of Phobos, in particular the presence of water (ice) (absorption bands at 1.5, 2.0 and 3.0-3.2 µm), hydrous silicate minerals (at 2.7-2.8 µm), minor overtones (at 1.4 and 1.8 µm), anhydrous silicates (features in the 0.9-1.0 and 2.0 µm regions) and the organic matter (3.3-3.5 µm). Particularly of interest will be the spectral investigation and differences of both the red and blue units on Phobos.

MIRS will also allow to measure the surface temperature of Phobos. This measurement is of paramount importance to remove the thermal contribution in the spectra longward of about 2.5 µm and be able to investigate spectral signatures in the region of the phyllosilicate and water bands (around 2.7 – 3.2 µm).

In addition, the surface thermal inertia of Phobos can be derived from temperatures measurements at different phase angles. Thermal Inertia will be computed for specific landing sites and will give insights on grain size distribution of the regolith and material porosity.

Other observations: Additional mission objectives are Deimos characterization and the Martian atmosphere. Thanks to successive flybys of Deimos, MIRS will characterize Deimos surface, compare with Phobos and help to decipher the Moons' origin. As for Mars, MIRS will be able to observe and constraint dust and water transport processes in the Martian atmosphere, by monitoring the distributions of dust content and storms, water ice clouds and water vapor.

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