Martian Moon eXploration (MMX) mission by Japan Aerospace Exploration Agency (JAXA) is the third Japanese sample return mission. One of the main mission goals is to decipher the origin of these moons, which will provide important clues on planetary formation and how water is delivered to inner planets.

MMX will be launched in September 2024 to Martian system to bring back samples from Phobos conducting detailed observations of Phobos and Deimos, and monitoring Mars’s climate. The mission is five-year round trip with return sample on Earth on July 2029. The spacecraft will arrive to Mars system on August 2025, stay three years, and have QSO (Quasi Satellite Orbits) around Phobos at different altitudes to select the landing sampling sites. The spacecraft will land for several hours on the Phobos surface to collect at least 10g of Phobos regolith using a corer going down to a depth of at least 2cm. MMX may collect Phobos samples in two different sites. After three years the spacecraft will leave the Martian system and return the samples to Earth, completing the first round-trip to the Martian system.

The principal objectives of the mission are:

- To settle the controversy on the origin of the Martian moons by close-up observations and return sample analysis
- To constrain processes for planetary formation and material transport in the region connecting the inner and outer solar systems
- To reveal evolutionary processes of the Martian system in the circum-Martian environments

A set of mission instruments are defined and under development to achieve the major mission goals.
The included instruments are: the wide-angle camera OROCHI (Optical RadiOmeter composed of CHromatic Imagers), the telescopic (narrow-angle) camera TENGOO (TElescopic Nadir imager for GeOmOrphology), the laser altimeter LIDAR (Light Detection and Ranging), CMDM (Circum-Martian Dust Monitor), MSA (Mass Spectrum Analyzer), MEGANE (Gamma rays and Neutrons Spectrometer) provided by NASA, a near-infrared spectrometer MIRS (MMX InfraRed Spectrometer) provided by CNES, SMP sampling device and the sample return capsule. A small Rover (total weight less than 30kg) developed by CNES and DLR is also a part of the mission. The Rover payload includes four scientific instruments: a IR radiometer (miniRAD), a Raman spectrometer (RAX), a stereo pair of cameras looking forward (NavCAM) and two cameras looking at the interface wheel-surface (WheelCAM) and consequent Phobos' regolith mechanical properties. ESA will participate to the mission assisting with deep space communication equipment.

1. MIRS

MIRS instrument is built at LESIA-Paris Observatory in collaboration with four other French laboratories (LAB, LATMOS, LAM, IRAP-OMP), with collaboration and financial support of CNES and close collaboration with JAXA and MELCO. MIRS is an imaging spectrometer in the 0.9 - 3.6 microns spectral band with spectral resolution better than 20 nm. The IFOV is 0.35 mrad and FOV of +/-1.65°. The SNR is higher than 100 up to 3.2 µm in a maximum integration time less than 2s. The detector has dimension of 256 x 256 pixels with pixel pitch of 30 microns. The total mass is lower than 11.9 kg (including 20% margin), and the volume of complete instrument is about 320 x 150 x 400 mm³.

2. MIRS science objectives

MIRS is expected to characterize Phobos and Deimos surfaces and Mars atmospheric composition by remotely identifying diagnostic features in the near-infrared range. MIRS is used to achieve some of the mission-requirements, in particular:

1: To grasp the surface distribution of the constituent materials of Phobos. Hydrous minerals and other related minerals should be identified and characterized spectroscopically for main parts of the full body in correspondence with its topography (at horizontal spatial resolutions of 20 m or better) and in a radius of 50 m or more around the sampling point (at spatial resolutions of 1 m or better).

For the global areas, MIRS is expected to spectroscopically measure water (ice) (absorption band at 3.0-3.2 µm) and hydrous silicate minerals (features at 2.7-2.8 µm) at the wavelength resolutions (wavelength width) of 20 nm, S/N ratios > 100 and a spatial resolution of 20 m (for +/-30° latitude). The spectral radiometric absolute accuracy is expected to be of 10%, and the relative accuracy of 1%. If possible, also to measure organic matter (3.3.-3.5 µm) and hydrous/anhydrous silicate minerals (1.0 µm). An area within 50 m from a selected sampling spot at 1 m resolution will be also mapped.

2: To grasp the distribution of constituent materials of Deimos, from spectroscopic information, clarify the surface distribution of hydrous minerals and other related minerals corresponding to its topography at characteristic parts of the moon with a horizontal spatial resolution of 100 m or better.

MIRS is expected to spectroscopically map major regions of Deimos at a spatial resolution better than 100 m for major absorption bands as observed in Phobos.

3: To constrain transport processes for dust and water near the Martian surface, continuous observations of the mid- to low-latitude distributions of dust storms, ice clouds, and water vapor in the Martian atmosphere are performed from high altitudes equatorial orbit in different seasons to within 1-hour time resolutions.

MIRS is expected to perform observations of distributions of total amount of water vapor columns at 10 km spatial resolutions and spectral radiometric absolute accuracy of 10%, and spectral radiometric relative accuracy of 1% with temporal resolution less than 1-hour for the mid- to low-latitude selected areas. These observations are expected to be performed over several successive
3. Conclusions

MIRS will allow compositional characterization of Phobos, Deimos and temporal characterization of particular phenomena of Mars atmosphere. It will be also a fundamental instrument to evaluate sampling site candidates and support the selection of the two sampling sites on the Phobos surface.

The mission will be able to clarify the origin of the Martian moons and may also be able to elucidate the process of the evolution of the Mars environment.

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