Development of near- and mid-infrared imaging spectrometers for the Martian moon's sample return mission and next generation space projects

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We report the current design of near-infrared spectrometer for the MMX (Mars Moon eXploration) mission, and also discuss near- and mid-infrared spectroscopy for next generation space projects with advanced imaging technology. MMX spacecraft is scheduled to be launched in the early 2020s, orbits Phobos and Deimos, and returns samples from Phobos back to Earth in the late 2020s. Near-infrared spectroscopy is useful to understand the material distribution on Martian moons (e.g., hydroxide minerals at 2.7 –2.8 um, hydrated minerals at 3.0 –3.2 um, and organics at 3.4 –3.4 um) and dynamics in Martian atmosphere (e.g. H2O at 2.5 –2.65 um, and pressure with CO2 absorption at 1.2 –2.2 um). We proposed a near-infrared spectrometer NIRS4 for the MMX mission to carry out the near-infrared spectroscopic measurement of the Martian moons Phobos and Deimos and Martian atmosphere. NIRS4 is based on the NIRS3 on the Hayabusa-2 spacecraft, which has a fast optics (F-number 1.4) with a long slit corresponds to a wide field-of-view (FOV) of 14.6 x 0.03 deg. NIRS4 covers the target area of 26 km length with 100 m spatial resolution looking from 100 km altitude. It also achieves 20 m and 1 m spatial resolution, respectively, from altitudes of 20 km and 1km. A grism is put in the collimating optics, and its wavelength resolution is ~ 1.5 to 3 nm (R~650 to 1000). A 2D HgCdTe array (640 x 512 pixel, pixel size 15 x 15 microns, sensitivity range 1 –3.8 microns) is used as a detector. The detector and optical system are cooled down below 90 K and 190 K with a Stirling cooler to reduce thermal noise. As an order sorter of dispersion light, we put 1– 1.9 um (1^{st} order) filter on a half part of the slit, and 1.9 –3.8 um (2^{nd} order) filter on the other half of the slit. In this way, a half FOV (7.3 x 0.03 deg) with wavelength range of 1 –1.9 um is focused on a half side of 2D detector (640 x 256 pixel area), and the other half FOV with wavelength of 1.9 –3.8 um is focused on the other half of the detector. The calibration lamp is used to determine the absolute wavelength. An optical chopping system which periodically interrupts an incident light to determine the background level precisely and to gain the signal-to-noise ratio.

Keywords: Mars, MMX, near-infrared spectrometer

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