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THERMAP : a mid-infrared spectro-imager for the Marco Polo R mission

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Abstract

We present THERMAP, a mid-infrared (8-16 μm) spectro-imager based on uncooled micro-bolometer detector arrays. Due to the recent technological development of these detectors, which have undergone significant improvements in the last decade, we wanted to test their performances for a space mission to small bodies in the inner Solar System. THERMAP was selected by ESA in January 2012 for a one year assessment study, in the framework of a call for declaration of interest in science instrumentation for the Marco Polo R Cosmic Vision mission. In this paper, we present some results of this study and in particular demonstrate that the new generation of uncooled micro-bolometer detectors has all the imaging and spectroscopic capabilities to fulfill the scientific objectives of the Marco Polo R mission.

THERMAP scientific objectives - The mid-infrared instrument of the Marco Polo R mission must be able i) to determine the surface temperature by mapping the entire surface with an absolute accuracy of at least 5 K (goal 1 K) above 200 K, ii) to determine the thermal inertia with an accuracy of 10% and iii) to determine the surface composition by mapping the entire surface with a spectral resolution of 70 between 8 and 16 μm. The above mappings should be performed with a spatial resolution of 10 m for the entire surface (global characterization) and 10 cm for the sampling sites (local characterization).

THERMAP imaging capabilities - In order to test the imaging capabilities of the THERMAP uncooled microbolometer detector, we set up an experiment based on a 640x480 ULIS micro-bolometer array, a germanium objective and a black body. Using the results of this experiment, we show that calibrated radiometric images can be obtained down to at least 258 K (lower limit of our experiment), and that two calibration points are sufficient to determine the absolute scene temperature with an accuracy better than 1.5 K. An extrapolation to lower temperatures provides an accuracy of about 5 K at 180 K, the lowest temperature the detector can measure.

THERMAP spectroscopic capabilites - In order to test the spectroscopic performances of the detector, we added flux attenuating neutral density mid-infrared filters (transmittance: 50%, 10%, 1%) to our experiment. Our results show that we can perform spectroscopic measurements with a spectral resolution R=40–80 in the wavelength range 8–16 μm for a scene temperature larger than 300 K, the typical surface temperature of a Near Earth Asteroid at 1 AU from the Sun.

THERMAP preliminary design - From the above results, we defined a preliminary design for the instrument. THERMAP is a mid-infrared (8-16 μm) spectro-imager based on two uncooled microbolometer arrays. It is composed of two channels, one for imaging and one for spectroscopy. A flip mirror allows switching between the two channels. Calibration is performed using deep space and two black bodies at known temperature. The design of the THERMAP instrument has a strong heritage from the MERTIS instrument on board Bepi-Colombo [1], which guarantees its feasibility and reliability. Our design is very flexible in term of operations, which is fundamental for a mission to a binary asteroid system (1996 FG3). The THERMAP instrument will be proposed for Marco Polo R and any future space missions to small bodies in the inner solar system.

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References

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