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THERMAP: the mid-infrared (8-16 μm) spectro-imager of the ESA Marco Polo R mission

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Abstract

THERMAP is a mid-infrared (8-16 μm) spectro-imager, selected by the European Space Agency (ESA) in February 2013 for the scientific payload of the Marco Polo R M-class mission. We present in this paper the instrument and its scientific objectives.

1 Scientific objectives of the THERMAP instrument

Although about 10 000 Near-Earth Asteroids (NEA) have currently been detected, only a few hundred have been observed in the mid-infrared (5-25 μm) from ground or space-based telescopes, mostly by the Spitzer Space Telescope, and none have been observed in-situ, spatially resolved, in this wavelength range. The mid-infrared window, which probes thermal emission, remains a completely unexplored field for space missions to NEAs. The THERMAP instrument, the mid-infrared spectro-imager of the ESA Marco Polo R mission, is specifically designed to fill this gap with the following scientific objectives:

- Characterize the surface thermal environment of a NEA: What is the surface temperature and degree of thermal stress weathering? What are the bulk thermal properties of the surface?

- Map the surface composition of a NEA: What is the surface mineralogical composition? What is the effect of space weathering on surface composition?

- Help to select the sampling site and to place the sample in its context: What is the surface thermal environment of the sampling site? What is the surface composition of the sampling site?

2 Instrument description and performances

THERMAP is a mid-infrared spectro-imager with two channels, one for imaging (8-18 μm) and one for spectroscopy (8-16 μm). Each channel is equipped with a 640x480 uncooled microbolometer array from the ULIS company (France).

The baseline for the THERMAP imaging channel is a tri-mirror anastigmat telescope (TMA), with a field of view of 9.5 deg x 7.0 deg, a focal length of 50 mm and an F-number of 2. The THERMAP imaging channel is a camera, with full 2D imaging capabilities, and can map the entire surface of the NEA or the sampling site in a few frames to derive its surface temperature distribution with an accuracy better than 5 K above 200 K.

The THERMAP spectroscopic channel is a slit spectrometer. It follows the imaging channel in the optical path, and is composed of a slit and an Offner relay with a spectral resolution of $\sim$0.3 μm over the 8-16 μm wavelength range.

The THERMAP instrument will acquire images and spectra of the targets during the different phases of the mission, with a spatial resolution of 10 m for the far global characterization, 5 m for the global characterization and 0.25 m for the local characterization of the sampling site. With its performances, THERMAP is the ideal instrument to characterize the surface thermal environment of a NEA, to map its surface composition and to help to select the sampling site and to put the sample in its context

Heritage - The THERMAP design follows the same philosophy than MERTIS, the Mercury Radiometer and Thermal Infrared Spectrometer for the ESA Bepi-

Colombo mission. It uses the same detector technology, i.e., uncooled micro-bolometer arrays, the same optical design, i.e., a tri-mirror anastigmat telescope (TMA) for imagery followed by an Offner relay for spectroscopy, and the same principle for calibration, i.e., a rotating mirror at the entrance of the instrument that can point alternatively the asteroid and three calibration targets (deep space and two black bodies).

3 THERMAP consortium

The THERMAP consortium is composed of three core institutes, contributing to the hardware: Labaroratoire d'Astrophysique de Marseille (LAM, France) that leads the consortium, Instituto de Astrofísica de Canarias (IAC, Spain – Lead scientist: Javier Licandro), and the Deutsches Zentrum für Luft-und Raumfahrt (DLR, Germany – Lead scientist: Jörn Helbert). The Principal Investigator of the THERMAP instrument is Olivier Groussin (LAM, France). LAM, IAC and DLR are major space science institutes in Europe, with a recognized expertise and an important contribution to past, current, or future space projects. The science team is composed of 17 members from 6 different countries (France, Germany, Spain, Sweeden, UK and USA), all with a strong expertise in asteroids and infrared observations. Several members of the team have already lead major scientific projects.

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