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THERMAP: a thermal infrared spectro-imager for space missions to small bodies of the solar system

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Abstract

In this paper, we report on an on-going feasibility study of a thermal spectro-imager for future space missions to small bodies in the Solar System (THERMAP). Thanks to the recent development of uncooled micro-bolometer technology, we decided to use such a detector as a baseline for our study. Here we present our progress on using this detector to perform: (i) uncalibrated images, (ii) calibrated radiometric images, (iii) spectroscopic measurements, and (iv) a definition of the instrumental concept including the optical and mechanical design.

1. Introduction

The thermal properties of small bodies in the Solar System extensively contribute to the knowledge of their global physical properties and dynamical evolution. Their determination allows us to constrain the surface properties (roughness, presence of regolith), the internal structure through the thermal inertia, and to quantify the Yarkovsky effect that controls the non-gravitational evolution of the orbit. The latter is particularly important for the prediction of the orbit of NEAs (Near Earth Asteroids), such as Apophis that could impact the Earth, hence for the design and development of future space missions to change the trajectory of those bodies. The thermal properties are best determined by the space-resolved mapping and spectroscopy of the surface of the body. This requires a specific and dedicated instrument, implemented on a spacecraft for a flyby, or better a rendezvous mission.

We are realizing the feasibility study of a thermal spectro-imager for future space missions to small bodies in the Solar System. With the recent progress of uncooled micro-bolometers (silicon detectors) technology and its space qualification under progress at CNES, we aim to use such an infrared (9-14 µm) detector as a baseline for our thermal spectro-imager.

2. Objectives

We have defined four objectives to be achieved in order to reach our goal.

1. Understand the behaviour of the detector and obtain uncalibrated images.

2. Define a calibration method and operational modes to obtain calibrated radiometric images (thermal imaging follows very different constraints than visible imaging).

3. Perform spectroscopic measurements to check their feasibility with such a detector and define the best suited spectroscopic technique.

4. Define the instrumental concept including the optical and mechanical design and build a demonstrator.

3. Experiment

A first experiment (Fig. 1) has been assembled to tackle the previously defined objectives. The set-up includes : i) an IRXCORE640 module from the INO company (Québec), based on a 640x480 micro-bolometer array from the ULIS company (France) [1], and its associated electronics (Fig. 2), ii) a Surnia Series germanium objective (f = 50 mm @ f# = 0.86) from the JANOS TECHNOLOGY company (USA), and iii) a metallic target with two heaters and a platinum temperature probe fixed on its surface.

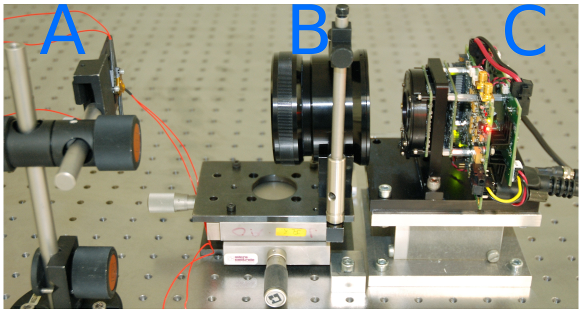

Figure 1: Our first experiment, with a heated metallic target (A), a germanium objective (B), and a micro-bolometer array detector (C).

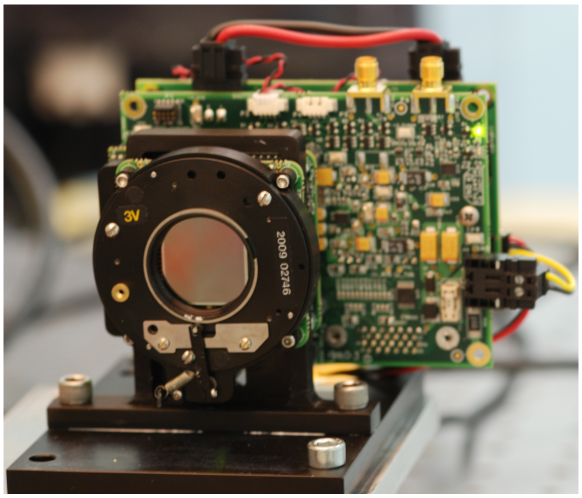

Figure 2: The IRXCORE640 module: a 640x480 micro-bolometer array (front) and its associated electronics (back).

To complete our first objective, several series of uncalibrated images (Fig. 3) were obtained while heating the target and monitoring its temperature from 20°C to 90°C. Thus, we were able to characterize the response of the detector for different integration times, gains, and detector working temperatures.

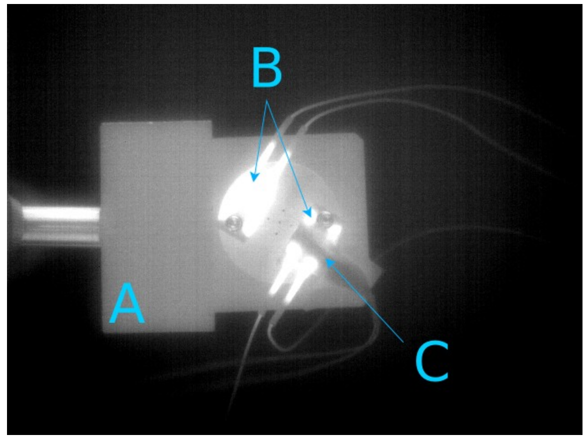

Figure 3: An uncalibrated image, featuring a metallic target (A), two heaters (B) held by screws, and a platinum temperature probe (C).

During this conference, we will show our progress on all the objectives of this work.

Acknowledgements

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References

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