EPSC Abstracts
Vol. 12, EPSC2018-809, 2018
European Planetary Science Congress 2018

Mapping Trojan Asteroids in the thermal infrared with TROTIS

J. Helbert (1), A. Maturilli (1), M. D'Amore(1), M. Grott (1), J. Knollenberg (1), G. Arnold (1), I. Varatharajan (1), E. Palomba (2), T. Okada (3), P. Vernazza (4), A. Rivkin (5), T. Müller (6), A. Börner (7), I. Walter (7)
(1) Institute for Planetary Research, DLR, Berlin, Germany, (2) INAF- Institute for Space Astrophysics and Planetology, Italy, (3) JAXA, Japan, (4) Laboratoire d'Astrophysique de Marseille, France, (5) JHU-APL, USA, (6) Max-Planck Institute, Gemany, (7) Institute for Optical Sensorsystems, DLR, Berlin, Germany (joern.helbert@dlr.de)

Abstract

TROTIS (TROjan asteroid Thermal Infrared multi-Spectral imager) is a high spatial-resolution thermal imaging system optimized for asteroid targets with heritage from the Miniaturized Asteroid thermal infrared Imager and Radiometer (MAIR) for the AIDA mission as well as the Bepi-Colombo mission's MErcury Radiometer and Thermal Infrared Spectrometer (MERTIS). Minor modifications of the three-mirror antistigma (TMA) optics and the updating of the discontinued ULIS microbolometer provide over five times better spatial resolution than the MERTIS instrument as well as an extension to shorter wavelength – potentially as far down as 2 µm.

1. Introduction

Mapping the surface of Trojan Asteroids in the thermal infrared will allow a set of complementary information important to understand the origin and evolutions of Trojan asteroids (see presentations by [1-2] at this meeting). Broadband thermal infrared imaging provides temperature maps from which thermophysical parameters can be derived. Narrow-band spectral imaging in this highly diagnostic spectral range allows deriving compositional information. Nightside radiometry will provide detailed information on the thermal inertia of the surface material. The combination of visual imaging and thermal imaging allows mapping day- and nightside and providing accurate shape models of the asteroids.

Thermal information provided by TROTIS will be crucial for selecting landing and sampling sites. The thermal infrared mapping will allow to link remote IR based studies on size, albedo, thermal inertia, grain size distribution, etc to the in-situ findings. This is especially important when trying to transfer the in-situ findings to other objects not visited by any spacecraft. Finally the thermal information also allows deriving limited sub-surface properties: for example young/old surface structures have different thermal properties (conductivity, compactness), providing information, which will complement the optical images.

A potential extension of the spectral coverage into the near infrared would significantly increase the science return.

2. TROTIS design concept

TROTIS builds more than a decade of development work at DLR for imaging spectrometer using uncooled microbolometers [3-10].

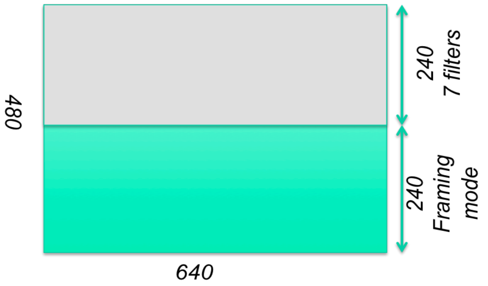

Figure 1: Microbolometer with filter strips and clear area allows simultaneous framing and multi-spectral imaging observations

TROTIS has two channels: a multispectral imager (microbolometer) and a radiometer that provides greater precision than the imager for background temperatures (80–150 K) over broad regions. The optical design is simplified from MERTIS, replacing the spectrometer with simple stripe filters (Figure 1). The microbolometer allows mineral absorptions and spatially resolved daytime temperatures to be characterized by collecting resolved images of the illuminated side of each asteroid over the wavelength range of 5–20 μm using a clear and several narrow filters positioned between 5–20 μm to characterize mineral absorptions and spatially resolved daytime temperatures. With the ongoing development on microbolometers the spectral coverage might be extended us far down as 2 μm.

The radiometer, which has lower spatial resolution but is more sensitive at low temperatures, provides the temperatures on the dark side of each asteroid that help constrain each asteroid's shape. Resolved temperature measurements enable thermal inertia estimates of the surface to be derived, while filtered emissivity data enable distinguishing bulk mineralogy.

TROTIS has a monoblock configuration (Figure 1), with the optical module mounted on top of electronic modules. It has a fully reflective, gold-coated F/2.5 TMA optical path with 135-mm focal length (TBC based on mission design). A flip-mirror selects the channel and serves as a calibration target for the imager. The flip-mirror follows the standard design used in a wide range of flight instruments. It is actuated by a flight-qualified, Faulhaber-type, 1016 DC motor and returns to microbolometer view when unpowered as a failsafe.

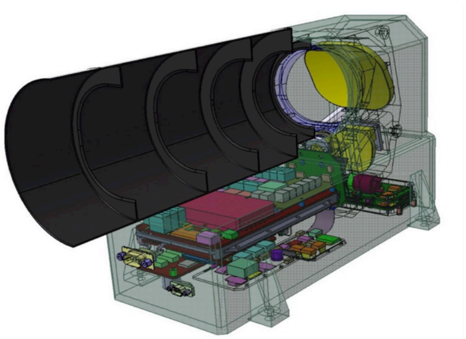

Figure 2: CAD model of current TROTIS design

TROTIS has a mass of 4kg and an average power consumption of 10W. The monoblock configuration allow for easy accommodation on any spacecraft bus.

The TROTIS sensor and electronics aluminum housing, with spot shielding as necessary, is sufficient to reduce TID to <100 krad (RDM 2). All components are immune to single event latchup and are rad-hard to >100 krad or spot shielded. Transient noise from energetic particles has an insignificant impact (smaller than read noise) on radiometer and microbolometer detectors.

3. Conclusion

TROTIS will provide unique science observations that will foster our understanding of Trojan asteroids. It will provide compositional information, thermal physical properties as well as accurate shapes. In addition TROTIS can aid optical navigation as it will be able to detect targets from any phase angle. The thermal information will also be very important to see, find and avoid very small satellites around the target body.

Based on the strong heritage the TROTIS design is currently assessed as TRL 6. No new development is necessary and all changes are standard engineering practice.

References

[1] A. Maturilli et al., this meeting.

[2] G. Arnold et al., this meeting.

[3] Walter, I., et al., *Deep space instrument design for thermal infrared imaging with MERTIS.* 2011. **8154**: p. 81540Y.

[4] Arnold, G.E., et al. *Thermal infrared imaging of Mercury-MERTIS-a new remote sensing technology*. 2009.

[5] Benkhoff, J. and J. Helbert, *Thermal infrared spectroscopy to investigate the composition of mercury – The MERTIS instrument on BepiColombo.* Advances in Space Research, 2006. **38**(4): p. 647-658.

[6] Brageot, E., et al. *THERMAP: a mid-infrared spectro-imager based on an uncooled micro-bolometer for space missions to small bodies of the solar system*. 2012.

[7] Helbert, J., et al., *MERTIS: from laboratory to Mercury.* 2008. **7082**: p. 70820L.

[8] Hiesinger, H. and J. Helbert, *The Mercury Radiometer and Thermal Infrared Spectrometer (MERTIS) for the BepiColombo mission.* Planetary and Space Science, 2010. **58**(1-2): p. 144-165.

[9] Peter, G., et al., *Developing of MERTIS as an advanced process from the study up to the flight model.* 2013. **8867**: p. 886707.

[10] Säuberlich, T., et al., *MERTIS: background signal removal and signal simulation.* 2009. **7453**: p. 745306.