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Measurement and stability of the pointing of the BepiColombo Laser Altimeter under thermal load

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Abstract

The first European laser altimeter, designed for interplanetary flight, BELA, (on BepiColombo mission to Mercury) will be launched in July 2016. This abstract describes the setup used to characterize the angular movements of BELA during the simulation of the environment that the instrument will encounter when orbiting Mercury. Tests performed using the Engineering Qualification Model (EQM) show that the setup is accurate enough to characterize angular movements of the instrument components with an accuracy of ≈ 10 μrad.

1. Introduction

BepiColombo mission consists of two spacecraft: the MPO (Mercury Planetary Orbiter) built by ESA and the MMO (Mercury Magnetospheric Orbiter) built by JAXA. It will investigate the origin and evolution of Mercury, of its magnetic field, its exosphere and will test Einstein's theory of general relativity [1]. BELA is one of the instruments onboard the MPO and will be nominally in a 400 km x 1508 km about Mercury with an orbital period of 2.3 h [2].

BELA consists of two subsystems: the transmitter (designed in Germany) and the receiver (designed in Switzerland) [3]. The transmitter and the receiver are mounted on a common baseplate which has an (almost) 0 CTE (Coefficient of Thermal Expansion) in order to limit the displacements of the transmitter/receiver over the temperature range to be experimented by the instrument. Although translations of the sub-systems with respect to each other are insignificant, small rotations can have major consequences. Two setups have been designed at the University of Bern; one to provide an accurate measurement of the alignment of the BELA instrument [4], and the other to verify that the instrument will remain aligned during one year operation in orbit around Mercury.

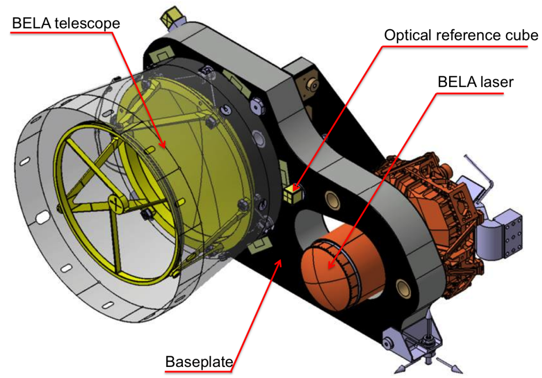

Figure 1: CAD model of the BELA instrument

2. Co-alignment of the BELA instrument at ambient

The instrument has been constructed with the co-alignment issues in mind. The 60 μrad wide laser beam must remain within the 450 μrad field of view of the receiver. The BELA instrument requires an accurate initial alignment (< 60 μrad). The current capability of the setup results in an accuracy of approximately 23 μrad [4], and therefore well within requirements. The transmitter and the receiver have to remain aligned to each other with this result as an initial starting condition.

3. Setup for stability tests of BELA under thermal vacuum conditions

Current models suggest that inside the BepiColombo spacecraft, the temperatures of the instruments will be kept within the range of 0°C - 40°C. For specific instruments, interface temperatures are outside this range [3]. BELA has an operational temperature range between -33°C and 58°C with the external baffles reaching a maximum value of 140°C when the Sun shines into the receiver telescope (at incidence angles between 38° and 90° from the boresight) [5]. To perform these tests, the BELA instrument is mounted inside a thermal-vacuum chamber. This chamber allows the instrument to be put under vacuum ($< 10^{-6}$ mbar), and simulates the temperatures that BELA will encounter.

The optical setup is divided in three sections to make separate but related measurements. The three sections measure the Telescope, the Optical Reference Cube and the BELA Laser angular displacements.

- Optical Reference Cube section : During the thermal-vacuum tests, the thermal-vacuum chamber where the instrument is mounted moves during pumping phase and when the temperature conditions change. The Optical Reference Cube section is the reference of the system and shows whether the angular movements are from the instrument or the thermal-vacuum chamber. This is achieved by monitoring a laser reflected from an optical cube on the instrument using a position sensitive detector.

- BELA laser section : This part of the setup detects the potential angular movements of the BELA laser using a beam attenuator and beam reducer to place the image on a CCD.

- Telescope section : This part of the setup detects the angular movements coming from the receiver part of the system. This is achieved by tilting a laser beam using a motorized flat mirror which scan the field of view of the receiver thanks to picomotors that move the mirror in two dimensions with an accuracy of 1 μrad. This scan light across the "single pixel" avalanche photodiode detector.

4. Results and discussion

The BELA Engineering Qualification Model has been aligned with an angular misalignment between the transmitter and the receiver equal to 41 $\pm$ 23 μrad following the alignment procedure.

Four cycles with a 91°C (from -33°C to 58°C) temperature range have been performed during the thermal-vacuum test on the Engineering Qualification Model of the BELA instrument, with different step

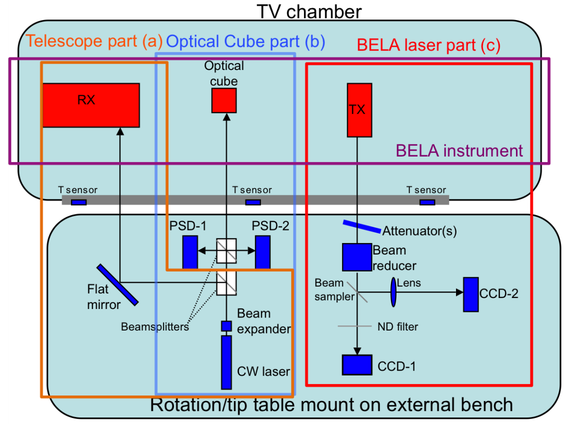

Figure 2: Setup for stability test of BELA under thermal-vacuum conditions

sizes between the maximum and the minimum temperatures. The instrument has been shown to be stable to an accuracy of 68 $\pm$ 12 μrad.

Acknowledgements

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References

[1] Grard, R., Returns to Mercury: science and mission objectives, Planetary and Space Science, Volume 49, Issue 14-15, p. 1395-1407

[2] Benkhoff, J. et al., BepiColombo Comprehensive exploration of Mercury: Mission overview and science goals, Planetary and Space Science, Volume 58, Issue 1-2, p. 2-20

[3] Thomas, N. et al., The BepiColombo Laser Altimeter (BELA): Concept and baseline design, Planetary and Space Science, Volume 55, Issue 10, p. 1398-1413

[4] Chakraborty, S. et al., High accuracy alignment facility for the receiver and transmitter of the BepiColombo Laser Altimeter, Applied Optics, vol. 51, issue 20, p. 4907

[5] Beck, T. et al., Thermal analysis of a reflective baffle designed for space applications, Acta Astronautica, Volume 69, Issue 5, p. 323-334