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The BepiColombo Laser Altimeter: Novel instrument elements

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Abstract

We present a description of some of the novel elements of the BepiColombo Laser Altimeter (BELA). Emphasis is placed on the laser, the baffles used to protect the sensitive parts of the instrument from the Sun, the telescope solution and the digital reangefinder system.

1. Introduction

The BepiColombo Laser Altimeter (BELA) is slated to fly on Mercury Planetary Orbiter (MPO) component of ESA's BepiColombo mission to Mercury. The instrument should perform topographic measurements and participate in the mission-wide geophysics experiment to study the interior of the planet. The instrument development is close to completion and contains a series of novel solutions to the requirements passed down to it from the mission and spacecraft design.

BELA is the first European laser altimeter to be built for inter-planetary flight. A key element has been the development of a European high-power (50 mJ) pulsed Nd:YAG laser allowing instrument operation at distances of > 1055 km from the target. The nadir-pointing geometry of MPO necessitated the use of baffles to reject the incoming sunlight (when MPO is over the nightside hemisphere but still illuminated by the Sun). The strict mass constraints combined with the expected large temperature excursions (arising in large part from the eccentricity of Mercury's orbit) drove the selection of a beryllium telescope as receiver. In addition, the competences within the participating countries led to adoption of a digital rangefinder concept. We discuss in a little more detail each of these elements below.

2. Instrument elements of note

a. Laser

The laser is a fully redundant 1064 nm Nd:YAG with 5 ns pulse duration and a nominal 50 mJ pulse energy. A beam expander collimates the beam to a 60 µrad width. The system can operate at up to 10 Hz, consumes 20 W and weighs < 5 kg (including MLI, cabling, beam expander, and drive electronics) [1].

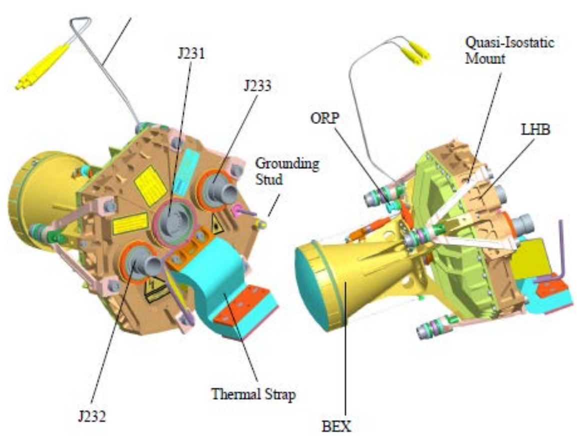

Figure 1 CAD/CAM of the laser head box from two angles.

b. Baffles

The receiver baffle follows a Stavroudis concept [2,3]. It is an aluminium structure combining ellipsoidal and hyperbolic surface machined with 4 nm roughness. The internal diameter is 204 mm and an extremely thin wall thickness has been achieved to minimize mass.

Although the transmitter baffle is smaller, it must also hold a thermal filter to prevent the beam expander focussing reflected light from Mercury on to the laser. A narrow band transmits the laser wavelength but rejects light outside a band around this wavelength.

c. Telescope

The receiver telescope is two-mirror on-axis design with a 20 cm primary. The telescope is an all-beryllium design and weighs roughly 600 g. The primary mirror is just 2 mm thick. The telescope surfaces have been produced using diamond-turning of a deposited copper layer followed by gold coating. The aperture at the vertex of the primary mirror is close to the focus of the telescope and supports the instrument straylight rejection concept.

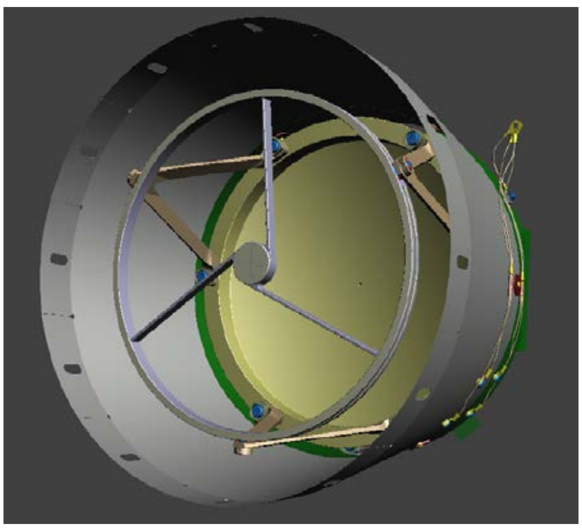

Figure 2 The receiver telescope which is being manufactured out of beryllium.

d. Rangefinder module

Unlike previous planetary laser altimeters, the rangefinding of BELA is performed using a digital approach where the signal is digitized and the return pulse detected using software in an FPGA. The resolution is limited by the digitization frequency and the bandwidth but tests indicate that in optimum conditions, accuracies of the order of 20 cm over the (typically) 500 km range can be achieved. The rangefinder can also detect fairly low return pulse energies. Testing indicates that a return pulse containing just 6 photons can be detected. The final system will have inferior performance because of noise contributions and the effects of radiation damage in flight. However, from a technological standpoint, the ranging system will meet the requirements foreseen in the original BELA proposal.

3. Conclusions

The first fully-functional model of the BELA instrument system is being integrated at the time of writing. The system contains a number of novel technologies which have required significant development. On the basis of this work, new solutions for specific space-related issues are now available. At least one new industrial company has been initiated on the basis of this program and several others have been able to optimize and improve their manufacturing capabilities by their participation. ESA now has access to a European source for this type of instrument for future missions.

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