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BepiColombo Laser Altimeter performance tests

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Abstract

The first European laser altimeter designed for interplanetary flight, BELA (BepiColombo Laser Altimeter) is ready to be integrated on the BepiColombo spacecraft to be launched to Mercury in July 2016 [1]. The flight instrument is currently installed in its calibration laboratory at the University of Bern where it is being tested to assess its performance. This abstract describes the different tests, run using data from Mercury and the Moon. Results on these ongoing tests will be presented in detail at the conference.

1 Introduction

BELA consists of two subsystems: the transmitter (designed in Germany) and the receiver (designed in Switzerland). It performs a Time-Of-Flight (TOF) topographic measurement. A few milliseconds after a laser pulse is sent toward the surface, a range window is opened to record the analogic signal from the detector. This signal is then digitalized and processed to detect the return pulse and calculate the TOF and complementary informations. It is required that the time resolution of the BELA instrument has to be $\leq$ 6.67 ns corresponding to a resolution $\leq$ 1m in order to produce a high resolution map of planet Mercury [2].

Contrary to the previous laser altimeters used for planetary research, which used analogue detection methods, BELA uses an innovative but complex digital pulse detection and characterization method. It uses fitting of the returned signal by one of several predefined pulse shape families to extract pulse shape parameters that provide information about the surface roughness and albedo.

2. Test setup

Unfortunately, it is impossible to perform a complete end to end test of the instrument before flight to evaluate its performance. For this reason, a test setup (Figure 1), which simulates scenarios that BELA could encounter during its mission, has been designed and constructed at the University of Bern. The goal of this setup is to simulate realistically a laser pulse reflected by the surface of Mercury in the laboratory. The emission of this simulated pulse is triggered by the actual BELA laser.

The transmitted pulse from the BELA laser is detected by a photodetector, connected to an oscilloscope, which triggers a waveform generator that simulate the shape of the pulse and its emission delay. A sequence file containing the pulse characteristics (pulse shape, pulse width) and the waiting time to simulate the TOF, is then sent from the waveform generator to the modulated laser which will emit the signal sent to the BELA receiver.

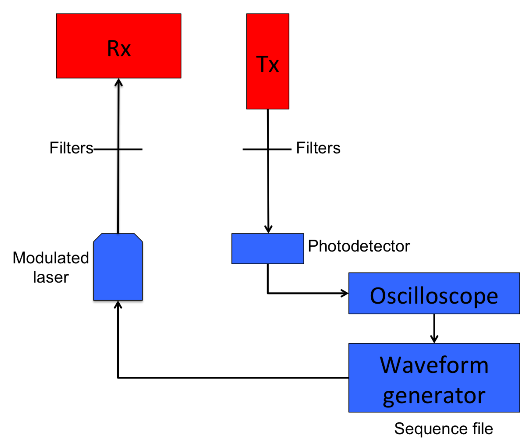

Figure 1: Schematic of the test setup

3. Scenarios and Results

Different test scenarios, that the system will encounter during its mission, have been chosen to evaluate the performance of the BELA instrument using different data sets.

- Scenario 1: the first and simplest test is to simulate a received gaussian pulse, corresponding to a flat surface with no roughness, in order to ensure that the TOF calculated by the instrument is correct with a time delay corresponding to an altitude between BELA and the surface of Mercury from 400 km to 1600 km [3], with step size of 100 km.

- Scenario 2: the MLA instrument onboard the MESSENGER spacecraft has been acquiring data since April 2011 [4]. These data are used to simulate various scenarios (just resolved crater, small scale roughness, sharp scarps). The MLA tracks will be loaded into the waveform generator to test the BELA range finding algorithm with realistic topography.

- Scenario 3: flat surface with surface roughness; this scenario simulates a flat surface, which returns the same pulse that the BELA laser sends to Mercury's surface, but with surface roughness which broadens the pulse by 10 ns, 20 ns, 50 ns and 100 ns.

- Scenario 4: in this scenario, instead of a gaussian pulse, we simulate the more complex and realistic pulse shapes that the system will encounter during its mission; this is done using realistic pulse waveforms simulated from high resolution Digital Terrain Models (DTM at 2m/pixel) of the Moon derived from Lunar Reconnaissance Orbiter Camera (LROC) stereo images [5]. These predicted return pulses will then be programmed into the waveform generator. It is thus possible to test the influence of the Moon's topography which presents similar surface features:
  - Scarp simulation : Scarps (surface expression of thrust faults) are smaller on the Moon but comparable to the ones which can be found on Mercury [6] (Figure 2).
  - Just resolved craters: to simulate a case where the size of the BELA laser footprint is the same as the size of the impact crater.
  - Unresolved craters: to simulate a case where the impact crater is smaller than the BELA laser footprint on the surface of Mercury

- Scenario 5: loss due to low energy signal simulation; the energy of the laser will be decreased until the loss of the signal to better assess the probability to miss pulses because of the distance from the surface, the low albedo, or high slopes.

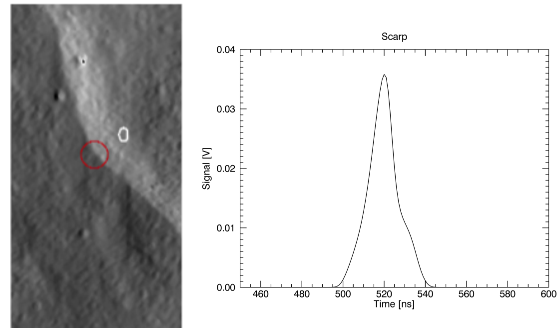

Figure 2: Left: DTM from LROC camera; right: waveform from the red spot on the DTM

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