EPSC Abstracts
Vol. 10, EPSC2015-551, 2015
European Planetary Science Congress 2015

The Ganymede Laser Altimeter (GALA) for ESA's JUICE Mission

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Abstract

The Ganymede Laser Altimeter (GALA) is one of the instruments selected for ESA's JUICE mission (Jupiter Icy Moons Explorer) [1]. The scientific goals of the GALA instrument cover a wide range of questions of geology, geophysics and geodesy. Here we will present an overview on the scientific goals and performance as well as an update on the instrument status.

1. Introduction

A fundamental goal of any exploratory space mission is to characterize and measure the figure, topography, and rotation of the target bodies. This is essential for understanding both the interior state and global aspects of satellite evolution as well as regional and local processes that have shaped the body's surface. A state of the art tool for this task is a laser altimeter because it can provide absolute topographic height and position with respect to a Ganymede (or Europa/Callisto) centered co-ordinate system.

2. Scientific Goals

With respect to Ganymede, the GALA instrument aims at

• the global subsurface ocean and further characterization of the water-ice/liquid shell by monitoring the dynamic response of the ice shell to tidal forces
• global, regional and local topography to understand the processes that have shaped Ganymede's surface
• measurements of forced physical libration and spin-axis obliquity that would provide additional information on the existence and extent of a subsurface ocean
• provide accurate data for determining Ganymede's shape (a, b and c-axis) low- and high-degree topographic measurements
• detailed topographic profiles crossing the linear features of grooved terrains.
• as well as at information about slope, roughness and albedo (at 1064nm) data from Ganymede's surface

During flybys of Europa and Callisto GALA will provide topographic profiles during closest approach for geological interpretation as well as providing constraints for shape measurements of these two satellites.

GALA will form an integral part of a larger geodesy and geophysics package, incorporating radio science, stereo imaging and sub-surface radar. The synergy will tackle the problems of planetary figure, rotation, gravity field determination, interior structure, surface morphology and geology, and tidal deformations. By interpreting the tidal measurement, the presence of an ocean can be confirmed and the ice shell thickness can be constrained by a few tens of km [2].

The latter is crucial for the detection of subsurface oceans on Ganymede (and on Europa and Callisto).

Precise time-of-flight measurements could improve the high-precision determination of the spacecraft position during the inter-planetary cruise and in the later orbital phases around Jupiter and Ganymede. The technical feasibility of laser links between Earth and the JUICE spacecraft is therefore also studied for GALA.

2. The Instrument

The principle of laser altimetry is straightforward. The time of flight between the emission of a photon and the receipt of the reflected photon is measured. This time of flight is then converted to a distance using the well-known speed of light. In a laser altimeter, a laser emits a short laser pulse, which is reflected from the surface of the body, received by a telescope and then analyzed by an electronic.

The instrument is designed to work at in circular orbit at 500 km altitude (GCO-500). Measurements with high accuracy during flybys at Europa and Callisto as well as in lower orbits around Ganymede are possible as well.

As pumping scheme, side-pumping is proposed here due to reduced technical complexity and heritage from the BELA transmitter laser. Redundancy can be realized easily with this scheme on diode stack level. Table 1 gives an overview on the transmitter sub-system Basic instrument parameters.

The GALA instrument is developed in collaboration of institutes from Germany, Japan, Switzerland and Spain.

Parameter	Value/description	Unit
Laser rod crystal	Nd:YAG	N/A
Wavelength	1064	nm
Pulse energy	17	mJ
Pulse repetition rate	30	Hz
Q-Switch	RTP pockels cell	N/A
Collimator aperture	ca. 45 x 60	mm
Divergence (full cone)	100	µrad
Receiver Telescope diameter	25	cm
Detector	Silicon APD,	
Detector electronics	100 MHz bandwidth digital rangefinder, 200 MHz sampling rate,	

6. Summary and Conclusions

The diversity of targets and the different phases of the trajectory including flybys and the Ganymede orbital phase during the course of the JUICE mission require flexibility of the instrument to achieve the various scientific objectives. The instrument is capable of achieving the scientific goals related to geology, geophysics and geodesy will be covered.

References

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