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The Ganymede Laser Altimeter (GALA)

H. Hussmann[1], K. Lingenauber[1], J. Oberst[1], M. Kobayashi[2], N. Namiki[2], J. Kimura[3], N. Thomas[4], L. Lara[5], **G. Steinbrügge**[1], and the GALA Team
(1) Institute of planetary research, DLR, Berlin, Germany (Hauke.Hussmann@dlr.de), (2) Chiba Institute of Technology, Narashino city, Japan, (3) Earth and Life Science Institute, Tokyo Tech. (4) Physikalisches Institut, University of Bern, Bern, Switzerland (5) Institute of Astrophysics Andalucia (CSIC)

Abstract

The Ganymede Laser Altimeter (GALA) is one of the instruments selected for the first ESA large class mission JUICE. 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 as well as on the instrument baseline design concept and the current performance analysis.

1. Introduction

The Ganymede Laser Altimeter (GALA) as part of the JUICE payload is one of the instruments focusing on aspects related to the presence and characterizations of subsurface water oceans. For the first time the time-variability of the global figure of a moon due to tides exerted by Jupiter will be detected by altimetry measurements.

By characterizing in detail Jupiter's moon Ganymede the JUICE spacecraft will be the first mission to orbit a satellite of the Solar System other than the Earth's Moon. In addition, flybys at Europa and Callisto will deepen our understanding of the current state and evolution of the Jovian satellite system. GALA will provide fundamental knowledge about Ganymede, Europa and Callisto and will, in combination with other instruments, lay the ground for further exploration of the Galilean satellites by future in-situ missions (e.g., landers or penetrators).

2. Scientific goals

A fundamental goal of any exploratory space mission is to characterize and measure the shape, topography, and rotation of the target bodies. This is essential for understanding 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 reference system.

With respect to evolution of the Galilean moons, the GALA instrument aims at

• the prove of existence of a global subsurface ocean and further characterization of the water-ice/liquid shell by monitoring the dynamic response of the ice shell to tidal forces.
• measurements of forced physical libration and spin-axis obliquity that would provide additional information on the existence and extent of a subsurface ocean [1]
• provide accurate data for determining Ganymede's shape (A, B and C-axis), local- and global 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

Further 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 shape, rotation, gravity field determination, interior structure, surface morphology and geology, and tidal deformations. 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 as an option for GALA.

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3. The Instrument

The principle of laser altimetry is straightforward. 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 unit. The time of flight between the emission of a pulse and the receipt of the reflected pulse is measured. This time of flight is converted to a distance using the speed of light.

The variation of orbit height between 500 km circular orbit (GCO-500) and 200 km (GCO-200) requires two different laser pulse energies at different pulse repetition rates to fulfill the performance requirements. Different designs for a laser resonator have been assessed in a technology study. A two resonator design is assumed to be most appropriate for JUICE mission and would consist of a stable resonator optimized for GCO-200 scenario with about 2.8 mJ and another unstable resonator which is optimized for GCO-500 scenario for 17 mJ.

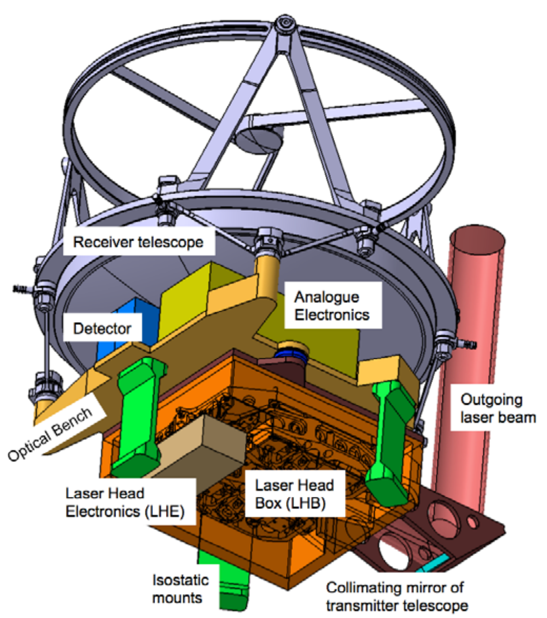

Figure 1: The GALA instrument

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 parameters. Performance analyses show that the GALA instrument will be able to operate to an altitude of 1300 km and has good signal to noise ratios even when operating in Ganymede's orbit on high sloped terrain or terrain with low albedo.

Table 1: Transmitter sub-system parameters

Parameter	Value/description	Unit
Laser rod crystal	Nd:YAG	N/A
Wavelength	1064	nm
Pulse energy GCO-200	2.8	mJ
Pulse energy GCO-500	17	mJ
Pulse repetition rate GCO-200	75	Hz
Pulse repetition rate GCO-500	30	Hz
Q-Switch	RTP pockels cell	N/A
Collimator aperture	ca. 45 x 60	mm
Divergence (full cone)	100	µrad
Mirror material	RSA-6161	N/A

5. Summary and Conclusions

The diversity of targets and the different phases of the trajectory including flybys and orbital phases during the course of the JUICE mission require flexibility of the instrument to achieve the various scientific objectives. Therefore GALA is built up on a two resonator design in order to fulfill the scientific requirements. During the mission a wide range of questions related to geology, geophysics and geodesy will be covered.

References

[1] Rose-Marie Baland, Marie Yseboodt, Tim Van Hoolst: Obliquity of the Galilean satellites: The influence of a global internal liquid layer, May 2012, Icarus 220, 435-448

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