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Study of the ice shells and possible subsurface oceans of the Galilean satellites using laser altimeters on board the Europa and Ganymede orbiters JEO and JGO

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Abstract

Laser altimetry is a powerful tool to map planetary surfaces. In addition to the static topography, time-dependent variations such as libration and tidal elevation can be extracted from laser altimeter data in order to investigate the interior structure of the planetary body. The most important objectives of the Europa Jupiter Science Mission (EJSM) proposed in the frame of ESA's Cosmic Vision Programme are the answer to the question whether the icy Galilean satellites contain subsurface oceans and whether they host habitable worlds. Both the Jupiter Europa Orbiter (JEO) and the Jupiter Ganymede Orbiter (JGO) of EJSM will carry laser altimeters as part of their core scientific payload. In the frame of the BepiColombo Laser Altimeter (BELA) project, we have carried out numerical simulations in order to estimate the uncertainty of the tidal and forced libration amplitudes of Mercury's surface to be extracted from topography data. These algorithms are now applied to the cases of the JEO and JGO laser altimeters in order to optimize the proposed instrument design for high science return.

Introduction

The envisaged studies of the icy satellites of Jupiter are motivated by the search for extraterrestrial life. Most models predict the existence of subsurface water oceans which may host life [1, 7, 8, 9, 10, 11]. Hussmann, H. et al. (2006, [2]) provide a more complete analysis under which conditions globe-encircling liquid reservoirs could also have survived to the present day on mid-sized icy satellites and large Kuiper belt objects. The first step to get insight into these planetary bodies is the determination of the gravity coefficients, Love numbers, and libration amplitudes by geodetic observations.

In the frame of the EJSM mission it has been proposed to apply laser altimetry to measure the tidal Love numbers h_n and l_n (n: spherical harmonic degree) of the radial and lateral deformation of the icy Galilean satellites Europa, Ganymede, and Callisto. For all these planetary bodies, the tidal elevation of the solid surface is rather large, if there is a liquid layer in the interior, while the tidal elevation is very small, if the interior is entirely solid. The topographic measurements require a precise knowledge on the spacecraft position which shall be gained by laser ranging to the Earth. The topographic measurements will complement the gravity data from the radio science experiments on board JEO and JGO and stereo imagery data in order to invert for the satellite interior structure.

Scope of simulations and analysis method

Laser altimeter parameter studies in combination with spacecraft orbit simulations shall lead to an optimized instrument design. This includes the required laser performance, number of laser shots taking into account detection probabilities, number of cross-over points to necessary to derive time-dependent surface deformations independently of the full extraction of the global topography, and an upper limit for the separation of ground tracks etc. [3].

Europa's and Ganymede's surface will be mapped from spherical near-polar spacecraft orbits which guarantee a dense coverage of all latitudes and longitudes by laser shots. However, the JGO Callisto campaign includes flybys only. Therefore, two kinds of analysis methods will be applied:

- the simultaneous extraction of the static topography expressed in form of a spherical harmonic expansion and the time-dependent libration and tidal elevation from laser altimeter data records densely covering the planetary surface.
- the extraction of the tidal Love numbers h_n from observations at crossing points of the spacecraft ground tracks on the planetary surface. If the spacecraft passes these points at times of different tidal phase angles, the tidal amplitude can be calculated from the difference of the topographic measurements at these points.

Koch et al. (2008,2009b) report on results for extracting Mercury's tidal Love number h_2 in the frame of the BepiColombo mission with laser altimetry [4, 6] using the first method. Koch et al. (2009a, [5]) describe the prospects for extracting the tidal Love number h_2 for the icy Galilean satellites using the second method. Here, we analyze the results applying the first method to the icy Galilean satellites. The achievable precision is rather high as the tidal amplitudes are 30 m and 7 m for Europa and Ganymede, respectively, provided they contain subsurface oceans.

In our simulations, we use synthetic laser altimeter data and expand the extracted topography into static local basis functions defined near the points of a rectangular grid [6] and into time-dependent basis functions describing the tidal elevation and librations. The static topography values are transformed into a spherical harmonic expansion, and the extracted coefficients of this expansion are compared to the original coefficients which had been used to simulate the yet unknown topography of the icy satellite. These input coefficients are based on the assumption that the topography of the icy Galilean satellites is somewhat subdued when compared to the Moon.

Bibliography

References

[1] Hurford, T. et al. (2007), *Nature*, 447, 292.

[2] Hussmann, H. et al. (2006), *Icarus*, 185, 258.

[3] Hussmann, H. (2009), .

[4] Koch, C. et al. (2008), *Planet. Space Sci.*, 56, 1226.

[5] Koch, C. et al. (2009a), *Advances of Geoscience*, accepted.

[6] Koch, C. et al. (2009b), *Planet. Space Sci.*, in preparation.

[7] Mitri, G. et al. (2008), *Icarus*, 196, 216.

[8] Moore, W. and Schubert, G. (2003), *Icarus*, 166, 223.

[9] Rappaport, N. et al. (2008), *Icarus*, 194, 711.

[10] Sohl, F. et al. (2003), *J. Geophys. Res.*, 108, 5130.

[11] Tobie, G. et al.(2003), *J. Geophys. Res.*, 108, 5124.