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Probing Jupiter's moons' interiors with tidal deformation and magnetic fields

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The magnetic data returned by the Galileo spacecraft have suggested that deep salted water oceans are present within Europa, Ganymede and Callisto [1,2]. As these three moons are subjected to significant tidal deformation, the presence of an internal ocean on these three icy moons is predicted to result in both a significant deflection of their surface and internal mass redistribution [3,4,5,6]. Altimetric or/and gravimetric measurements to be performed by the EJSM spacecrafts should be able to confirm the presence of the internal oceans by monitoring the periodic surface deflection and gravity change. However, these measurements alone will not be able to constrain the thickness of the ice shell, as the tidal deformation significantly depends on the unconstrained shear modulus of the ice shell and the physical properties of the subsurface ocean.

Here we investigate whether the ice shell thickness and ocean properties can be better constrained by combining the static gravity field, periodic altimetric and gravimetric fluctuations and magnetic signals. We test the sensitivity of the tidal response and electric conductivity to the ice shell and ocean properties (thickness, shear and bulk modulus, electrolyte content, degree of stratification, temperature profile etc.).

By solving the equations of motion for a compressible viscoelastic layered interior subjected to time-varying potential [7], we predict that the tidal response of Europa is primarily sensitive to the ice shell thickness and to the density of the water ocean (almost insensitive to ice density, iron core and mantle size and state). In the absence of additional constraints on the ocean composition, the uncertainty on the ice shell thickness from altimetric and gravimetric measurements will be larger than 15-20 km.

Only a joint inversion of the entire geophysical dataset, including low-degree static gravity field and topography, tidal fluctuation (k_2 and h_2), magnetic

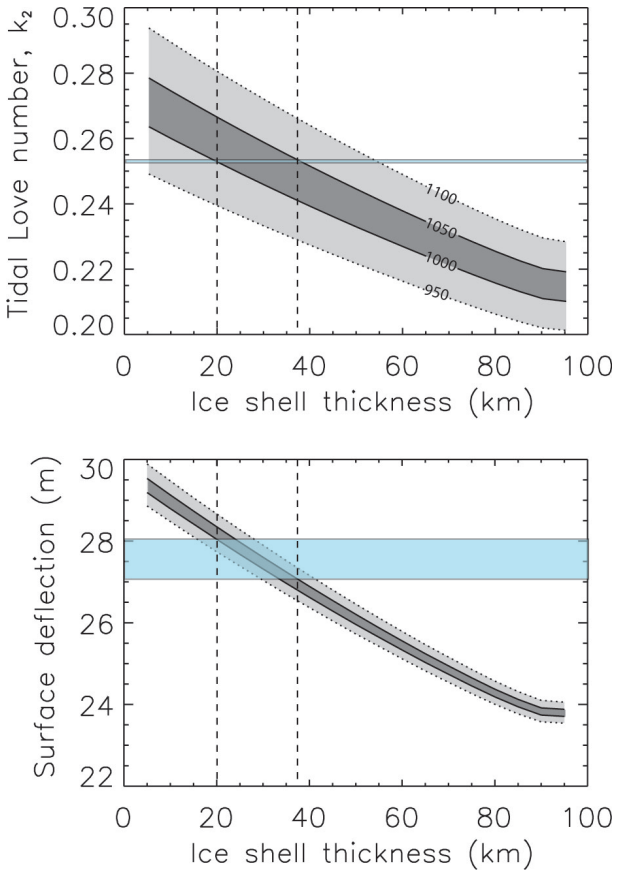

Figure 1: *Gravimetric (k2) and altimetric signatures of tidal deformation on Europa as a function of ice shell thickness and water density. The blue band indicates the expected accuracy of measurements to be performed by the Jupiter Europa Orbiter.*

induction, would permit us to reduce the uncertainty on the ice shell thickness (<5-10 km). Following the method of Verhoeven et al. [8], we are currently developing an algorithm enabling to invert jointly these different data. This approach will permit us to determine the most probable solutions in term of ice shell and ocean thicknesses, oceanic salt content as well as degree of differentiation of the deep interior.

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