

ROTATION OF A VISCOELASTIC, SYNCHRONOUS CRUST

B. Noyelles

NaXys, University of Namur, Rempart de la Vierge 8, B-5000 Namur, Belgium

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The space missions Galileo and Cassini have revealed the presence of several subsurface ocean for mid-sized icy moons, like Europa, Ganymede, Enceladus, or Titan. The viscoelastic deformations of the icy crusts coating the oceans can strongly affect the rotational response to the tidal torque of the parent body [1], in particular they lower the amplitude of the physical librations [6, 5]. The goal of this study is to give a comprehensive overview of the rotational response of a viscoelastic crust to the tidal forcing of its parent planet. I stress in particular how the librations and the obliquity will be affected, in considering the frequency-dependent rheology.

I use both the analytical and the numerical tools. From the analytical study I propose a new way to see the librations and the obliquity, based on the geometry of the tidal torque. The numerical study consists to model the 3 rotational degrees of freedom simultaneously, i.e. the longitude, latitude, and polar motion, in propagating the relevant equations. They include a complete modeling of the position of the parent planet, from orbital ephemerides [3]. These ephemerides stress the influence of different frequencies present in the dynamics, because of the gravitational perturbations of the other satellites. Two tidal models are considered, i.e. the classical Maxwell model, and the Andrade one that is more relevant for high-frequency excitations [2]. A digital filtering, based on frequency analysis [4], is used to model the time variations of the tensor of inertia. The Maxwell time τ_M plays a critical role, as a limit between the elastic and the anelastic behaviours (Fig. 1). The results are tested in modeling the rotation and the deformations of the Jovian satellite Europa.

I get a numerical modeling of the 3 degrees-of-freedom rotation of a viscoelastic, synchronous crust. It combines the rotational response with the tidal deformation of the body. It not only confirms the influence of the elasticity on the amplitude and phase of the longitudinal and latitudinal librations, but also provides clues on the future possibilities to validate or discard some tidal models from observations of the rotation.

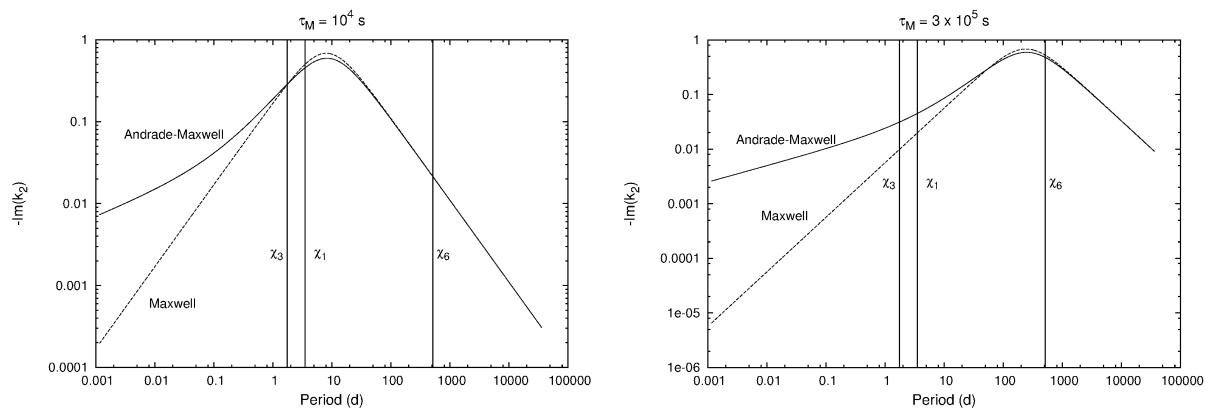


Figure 1. Dependency of the imaginary part of the tidal Love number k_2^s with respect to the tidal frequency. The 3 vertical lines locate the frequencies χ_1 , χ_3 and χ_6 , present in the forced rotational dynamics of Europa. They correspond to the periods 3.52546, 1.76273 and 509.26890 days, respectively. τ_M is the Maxwell time.

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