Non-equilibrium tides of Europa

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The Jovian moon Europa experiences time-variable tides as it travels around Jupiter on
an eccentric orbit. Observations suggest that the interior contains a layer of liquid wa-
ter underlying an icy crust. Measurements of the tides can provide further evidence for
a subsurface ocean and can be used to estimate the thickness of the icy shell. The tidal
response of planets and satellites is conventionally determined by solving the visco-
elastic deformation problem in the approximation of an infinite tidal period. These
models do not consider the internal dynamics of the liquid layers and the response
of the ocean is considered as that of an equilibrium (gravitational) tide, although the
ocean dynamics could affect the amplitude of the tidal surface displacements. In this
paper, a comparison is made between a finite-element ocean model forced by the tidal
potential of Europa and a visco-elastic deformation model. We show that the non-
equilibrium part of the tides can be significant.