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Tidal resonance in icy satellites with subsurface oceans

KAMATA, Shunichi[1*] ; MATSUYAMA, Isamu[2] ; NIMMO, Francis[3]

[1]Hokkaido Univ., [2]LPL/Univ. Arizona, [3]UC Santa Cruz

Tidal dissipation is a major heat source for the icy satellites of the giant planets. Several icy satellites likely possess a subsurface ocean underneath an ice shell. Previous studies of tidal dissipation on icy satellites, however, have either assumed a static ocean, or ignored the effect of an ice lid on subsurface ocean dynamics. In this study, we extend the formulation for tidal deformation based on the viscoelasto-gravitational theory to incorporate inertial effects and obtain a comprehensive equation system that can be applied to a model with a dynamic ocean overlain by an ice lid. Although ocean dynamics are treated in a simplified fashion, we find a resonant configuration when the phase velocity of gravity waves approaches the orbital velocity. The enhanced deformation near the resonant configuration would lead to significantly enhanced tidal heating in the solid lid. A static ocean formulation would give an accurate result only if the ocean thickness is larger than the resonant thickness by a factor of about one hundred. The resonant configuration strongly depends on properties of the shell, demonstrating the importance of the presence of a shell on tidal dissipation.

Keywords: Icy satellites, Subsurface ocean, Tidal response, Resonance