Forced libration of Ganymede: including visco-elastic tidal deformations

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Most of solid bodies which are beyond Jupiter are covered by ice and therefore called icy bodies. Based on previous observations and theoretical works, some of these bodies are presumed to possess a subsurface ocean where extraterrestrial organism might exist.
Jovian moon Ganymede is one of these body and is the main target of a future Jovian exploration mission. A past exploration revealed that Ganymede has a small moment of inertia and an intrinsic magnetic field. These observational facts indicate that Ganymede has a fully differentiated interior composed of a metallic core at the center, rocky mantle, and the outermost ice shell. Although a magnetic observation by the past exploration indicates that the salty subsurface ocean exists within the shell, the existence of the ocean is still ambiguous. Therefore, this study uses libration as an alternative method for presuming the interior of Ganymede.
In recent years, a libration study for Ganymede has included an elastic tidal deformation. Consequently, the deformation strongly reduces a librational amplitude in the case with the ocean. On the other hand, the librational amplitude is comparable even in the case without the ocean. Their study concluded the amplitude cannot provide the information of the existence of the ocean. Although other study for Europa included the effect of viscosity, the viscosity profile in the ice shell of its model is considerably simplified, thus a refined model is needed.
In our study, we apply the refined interior model to calculate librational amplitudes and phase-lag including the amplitude and phase-lag of visco-elastic tidal deformations.
As a result, the librational amplitude reaches 110 m for a case with the ocean.
In contrast, the amplitude is up to 10 m for a case without the ocean. These contrasts provide the information of the existence of the ocean.
Also the librational phase-lag is useful to estimate a melting point viscosity at the bottom of the ice shell. These results will be examined in the next exploration mission named JUICE (JUpiter ICy moons Explorer).

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