Tidal response of Europan ice shell with subsurface ocean

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Europa is the second satellite of the Galilean satellites of Jupiter. Its radius is 1,570km and density is about 3.0g/cm^3. This satellite is especially unique in the solar system in some respects. The most unique feature is that it possibly possesses the ocean under ice crust. Indirect evidence for subsurface ocean has been obtained by recent observations by Galileo spacecraft. If there is subsurface ocean under the ice crust, the ice crust could rotate independently of the inner silicate core. Then, it might be significant to discuss about the shell oscillation due to the tidal interaction with Jupiter.

Since Europa has eccentricity due to the resonance among Io, Europa and Ganymede, tidal interaction by Jupiter exists on Europa. This interaction includes the tidal torque, which would cause some oscillation on the Europan ice shell.In considering a shell like Europan ice crust, we assume that the shell can rotate independently of its inner core. In addition, the moment of inertia of the shell is much less than the solid satellite, and the value of tidal torque increases from the center to the surface of the satellite. Thus, it is not certain whether the angular velocity of the shell changes or not. We have solved numerically the equation of motion of Europan ice shell, and we obtained that the Europan ice shell does not oscillate. This result shows that the subsurface ocean has no influence on the shell rotation and the tidal potential on the shell.

In addition, it is necessary for the model to take the global thickness distribution into account. The surface temperature data on Europa by Galileo spacecraft show that the temperature changes drastically between equatorial region and polar regions, and sub- and anti-Jovian hemisphere by the radiation of Sun and Jupiter. This surface temperature distribution might cause global thickness difference on the Europan ice shell. And the global thickness distribution can be obtained by some thermal assumptions.

We built the Europan ice shell model with global thickness distribution and considered the characteristic tidal response of the shell. The results show that the whole torque of the shell might be negative with some parameters because the tidal torque at some point on the shell changes between negative and positive trigonometrically. If negative tidal torque might be exerted on the shell, the lag angle increases and the shell rotates to some extent where the torque become positive. In this case, the shell rotation becomes unstable. Moreover, if we consider the tidal torque due to the obliquity and the shell model with thickness distribution, the torque on the shell becomes negative. In this case, there might be the different precessional oscillation between the shell and core.