Orbital and tidal evolution of Enceladus

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Among Saturn's mid-sized moons, only Enceladus is thermally active, which has been a big puzzle. We have performed numerical simulations of tidal orbital evolution of the Saturn's mid-sized moons and evaluated tidal heating in Enceladus.
The current heat flux of Enceladus was estimated as ~16 GW by Cassini's observation (Howett et al. 2011). If the time-averaged dissipation factor Q of Saturn is anticipated as ~18000, the heat production is estimated to be 1.1 GW (Meyer & Wisdom 2011), which is much smaller than the observed value. Recently, a smaller value of Q_{Saturn} (~1680) was suggested by astrometric data analysis (Lainey et al. 2010). If Q_{Saturn}=1680, the mid-sized satellite may have formed from the ring (Charnoz et al. 2011). In this model, Enceladus must be formed earlier than Tethys and their orbits must closely approach each other in the course of tidal orbital evolution.
Through numerical orbital integration taking into account tidal interactions, we found that Enceladus is captured at a mean-motion resonance with Tethys. Because Tethys is more massive and accordingly its orbital evolution is faster, Enceladus' semi-major axis is pushed by Tethys and its eccentricity is secularly increased until its orbit starts crossing with Tethys' orbit. Eventually, Enceladus is scattered inward and Enceladus and Tethys establish the current orbital order. After the inward scattering, Enceladus becomes isolated from Tethys and its large eccentricity is damped by tidal dissipation inside Enceladus. The heat generation may be large enough to account for the current heat flux. Because this process occurs only for Enceladus, it can explain why only Enceladus is thermally active.

Keywords: Enceladus, tidal heating, orbital evolution, mean motion resonance

