Tidal Dissipation in a Viscoelastic Saturnian Core and Expansion of Mimas’ Orbit

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Tidal dissipation in Saturn is usually parameterized by Saturn’s quality factor Q. However, there remains a discrepancy between conventional estimates and the latest determination that has been derived from astrometric observations of Saturn’s inner satellites. If dissipation in Saturn is as large as the astrometric observations suggest and independent of time and tidal frequency, conventional models predict that Mimas’ initial orbit should be located inside Saturn’s synchronous orbit or even inside its Roche limit, in contradiction with formation models. Using simple structure models and assuming Saturn’s core to be viscoelastic, we look for dissipation models which are consistent with both the latest observations and with Mimas’ orbital migration. Firstly, using a two-layer model of Saturn’s interior structure, we constrain the ranges of rigidity and viscosity which are consistent with Saturn’s dissipation derived from astrometric observations at the tidal frequencies of Enceladus, Tethys and Dione. Next, within the constrained viscosity and rigidity ranges, we calculate Mimas’ semi-major axis considering the frequency dependence of viscoelastic dissipation in Saturn’s core. We show that Mimas can stay outside the synchronous orbit and the Roche limit for 4.5 billion years of evolution. In the case of a frequency dependent viscoelastic dissipative core, the lower boundary of the observed Saturnian dissipation can be consistent with the orbital expansion of Mimas.In this model, the assumption of a late formation of Mimas, discussed recently, is not required.

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