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Tidal heating and orbital evolution of Enceladus

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In 2006, the Cassini flyby of Enceladus revealed an active, warm south polar terrain. Since then, much progress has been made on understanding the orbital and geophysical properties of Enceladus and the other Saturnian satellites. However, the anomalous heat flux on Enceladus remains a puzzle. I will review the orbital evolution of the Saturnian satellites, including the past and present resonances of Enceladus, and discuss the consequences for the tidal heating rate and constraints on the Q of Saturn.

Enceladus is currently in a 2:1 eccentricity-type mean motion resonance with Dione. This resonance excites the orbital eccentricity of Enceladus and causes tidal heating within the body. The equilibrium tidal heat production is 1.1 GW for a Q of Saturn of 18,000 (Meyer and Wisdom, 2007). Based on the dynamical characteristics of the resonance (Meyer and Wisdom, 2008a), Enceladus must be near orbital equilibrium in this resonance today. The current tidal heating rate should therefore be near this equilibrium heating rate.

Observational measurements of Enceladus' heating rate (Spencer et al, 2006, Howett et al, 2008) disagree with this theoretical prediction, which is independent of any assumptions about the rheology of Enceladus. Therefore, either Enceladus is in thermal disequilibrium or the Q of Saturn must be much lower than its minimum historical average of 18,000.