

Topics/Concepts

Tidal potential, tidal bulge, Roche limit, Love numbers

Phase lag, Q , tidal torqueEquations

$$\text{Tidal potential } V = -\frac{GM}{a^3} R^2 P_2(\cos \phi) = -HgP_2(\cos \phi) \quad \text{Equbm. tide} \quad H = R \frac{M}{m} \left(\frac{R}{a} \right)^3$$

$$\text{Love numbers (uniform body): } h_2 = \frac{5/2}{1 + \frac{19\mu}{2\rho gR}} \quad k_2 = \frac{3/2}{1 + \frac{19\mu}{2\rho gR}}$$

$$\text{Tidal lag} \quad \sin(2\varphi) \approx \frac{1}{Q} \quad \text{Tidal torque (non-synchronous)} \quad \frac{3}{2} k_2 m^2 G \frac{R_p^5}{a^6} \frac{1}{Q}$$

Numbers

$$G = 6.67 \times 10^{-11} \text{ m}^3 \text{ s}^{-2} \text{ kg}^{-1} \quad Q_{\text{solid}} \sim 10^2 \quad Q_{\text{gas}} \sim 10^5$$

Homogeneous, fluid body: $h_2 = 5/2$, $k_2 = 3/2$ ReferencesMurray, C.D., S.F. Dermott, *Solar System Dynamics*, CUP 1999, Chapter 4.Harrison, J.C., An analysis of the lunar tides, *JGR* 68, 4269-4280, 1963, Appendix 1.Wahr J.M. et al., Tides on Europa and the thickness of Europa's icy shell, *JGR* 111, 2006.Goldreich, P., S. Soter, Q in the solar system, *Icarus* 5, 375-389, 1966.