Dynamical Tides in Eccentric Massive Stellar Binaries

Group Meeting

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Setup

Problem Description

- Massive star with eccentric binary companion inducing dynamical tides.
- Primary difficulty: dynamical tides is typically messy, sum over many modes, hard to gain analytical intuition.
- Question: can we obtain a *simple closed form for dynamical tides* in this system?

- Dynamical tides in massive stars due to *circular companion* (Kushnir et. al. 2017).

$$\tau(\omega; r_c) = \beta_2 \frac{G M_2^2 r_c^5}{a^6} \left(\frac{\omega}{\sqrt{G M_c / r_c^3}} \right)^{8/3} \frac{\rho_c}{\bar{\rho}_c} \left(1 - \frac{\rho_c}{\bar{\rho}_c} \right)^2. \tag{1}$$

- Eccentric forcing is just sum of many circular forcings (Fourier transform, e.g. Vick et. al. 2017)

$$\tau = T_0 \sum_{N=-\infty}^{\infty} F_{N2}^2 \, \mathrm{sgn}(N\Omega - 2\Omega_s) \tau(\omega = |N\Omega - 2\Omega_s|), \tag{2}$$

where F_{Nm} are the *Hansen coefficients*

$$F_{Nm} = \frac{1}{\pi} \int_0^{\pi} \frac{\cos[N(E - e\sin E) - m f(E)]}{(1 - e\cos E)^2} \, \mathrm{d}E. \tag{3}$$

Solution

Key Insight

- Key insight: $e \to 1$, the Hansen coefficients can be well approximated in closed form, and their sum approximated as an integral.