Binary Stars - astro8501 - 6944

Problem Sheet 6

1. Show that the dynamical timescale of a star is approximately

$$\tau_{\rm dynamical} \approx \frac{1}{\sqrt{G\bar{\rho}}}.$$

2. Derive expressions for the dynamical, thermal and nuclear timescales for zero-age main sequence stars as a function of mass only. What would be the lifetime of the Sun assuming that nuclear reactions are impossible?

3. Derive the expression

$$\frac{\dot{P}}{P} = 3\left(\frac{M_1}{M_2} - 1\right)\frac{\dot{M}_1}{M_1}$$

for conservative mass transfer from star 1 of mass M_1 to star 2 of mass M_2 in a close binary with period P.

4. Derive the expressions for γ given in the lectures for a) an isotropic fast wind from the donor, b) isotropic emission from the accretor and c) a circumbinary disc of radius $a_{\rm CBdisc}$.

5. Given the approximate relation from Eggleton,

$$R_L \approx 0.44a\frac{q^{0.33}}{(1+q)^{0.2}}$$

where $q = M_1/M_2$, show that for conservative mass transfer,

$$\frac{\dot{R}_L}{R_L} = \left(2.13\frac{M_1}{M_2} - 1.67\right)\frac{\dot{M}_1}{M_1},$$

where star 1 is the donor and star 2 is the accretor. Hence what is the critical q for unstable (conservative) mass transfer?

6. Show that the Eddington luminosity for accretion is given by $L_{\rm Edd} \approx 4\pi GMm_pc/\sigma_T$ (and explain your assumptions) and hence estimate the constant $\mathcal{L}$ in $L_{\rm Edd} = \mathcal{L}\left(\frac{M}{\rm M_\odot}\right)$ erg s^{-1}. What is the equivalent limit on the accretion rate?

Questions, problems, errors? Contact Rob Izzard by email: izzard@astro.uni-bonn.de