Mass Transfer Rates

Kavli Summer Program

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Let's consider what the mass transfer rates for our stars should be. First let's just write some of the basic timescales. The nuclear timescale we can reduce assuming H core fusion and the mass-luminosity relation.

$$
\begin{aligned}
\tau_{\rm nuc} &\sim \frac{M f_M c^2 (\Delta m/m)}{L} && (1)\\
&\sim 7.1 \times 10^{-4} \frac{M c^2}{L} && (2)\\
&\sim 7.1 \times 10^{-4} \frac{\mathrm{M}_\odot c^2}{1.4\,\mathrm{L}_\odot} \left(\frac{M}{\mathrm{M}_\odot}\right)^{-2.5} && (3)
\end{aligned}
$$

$$
\boxed{\tau_{\rm nuc} \sim 7.5 \times 10^{9}\,\mathrm{yr} \left(\frac{M}{\mathrm{M}_\odot}\right)^{-2.5}} \tag{4}
$$

Then the thermal timescale is approximately:

$$
\begin{aligned}
\tau_{\rm therm} &\sim \frac{G M^2}{R L} && (5)\\
&\sim \frac{G\,\mathrm{M}_\odot^2}{1.4\,\mathrm{R}_\odot\,\mathrm{L}_\odot} \left(\frac{R}{\mathrm{R}_\odot}\right)^{-1} \left(\frac{M}{\mathrm{M}_\odot}\right)^{-1.5} && (6)
\end{aligned}
$$

$$
\boxed{\tau_{\rm therm} \sim 2.2 \times 10^{7}\,\mathrm{yr} \left(\frac{R}{\mathrm{R}_\odot}\right)^{-1} \left(\frac{M}{\mathrm{M}_\odot}\right)^{-1.5}} \tag{7}
$$

Now we can consider some different limits. Assuming that we accrete on a timescale of $\tau_{\rm accrete}$ (and that $\tau_{\rm therm} \ll \tau_{\rm nuc}$):

- $\tau_{\rm accrete} \gg \tau_{\rm nuc}$: If the accretion is much slower than the nuclear timescale then the star will exhaust a significant fraction (or all!) of its central hydrogen before accretion can complete. This is not very realistic.

- $\tau_{\rm accrete} \sim \tau_{\rm nuc}$:

- $\tau_{\rm accrete} \sim \tau_{\rm therm}$:

- $\tau_{\rm accrete} \ll \tau_{\rm therm}$: