Astrophysics of gravitational wave sources

Lecture 7: Common envelope & chemically-homogeneous evolution

Ondřej Pejcha

ÚTF MFF UK

Logarithmic change of the Roche lobe radius with orbital angular momentum and total mass fixed:

$$R'_{\rm L} \equiv \frac{{\rm d}\log R_{\rm L}}{{\rm d}\log M_1} = (1+q)\cdot\left(\frac{{\rm d}\log R_{\rm L}/a}{{\rm d}\log q} + \frac{{\rm d}\log a}{{\rm d}\log q}\right)$$
$$\approx 2.13q - 1.67, \quad 0 < q \lesssim 50;$$

Polytrope with $\gamma = 5/3$ has adiabatic $R \sim M^{-1/3}$, which leads to critical q

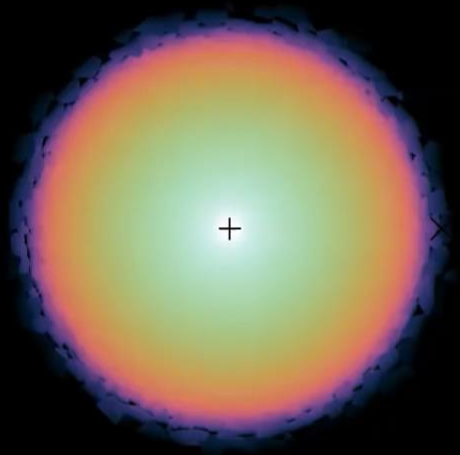
Dynamical instability -> total energy conserved

(Eggleton's book)

Calculation of energy balance

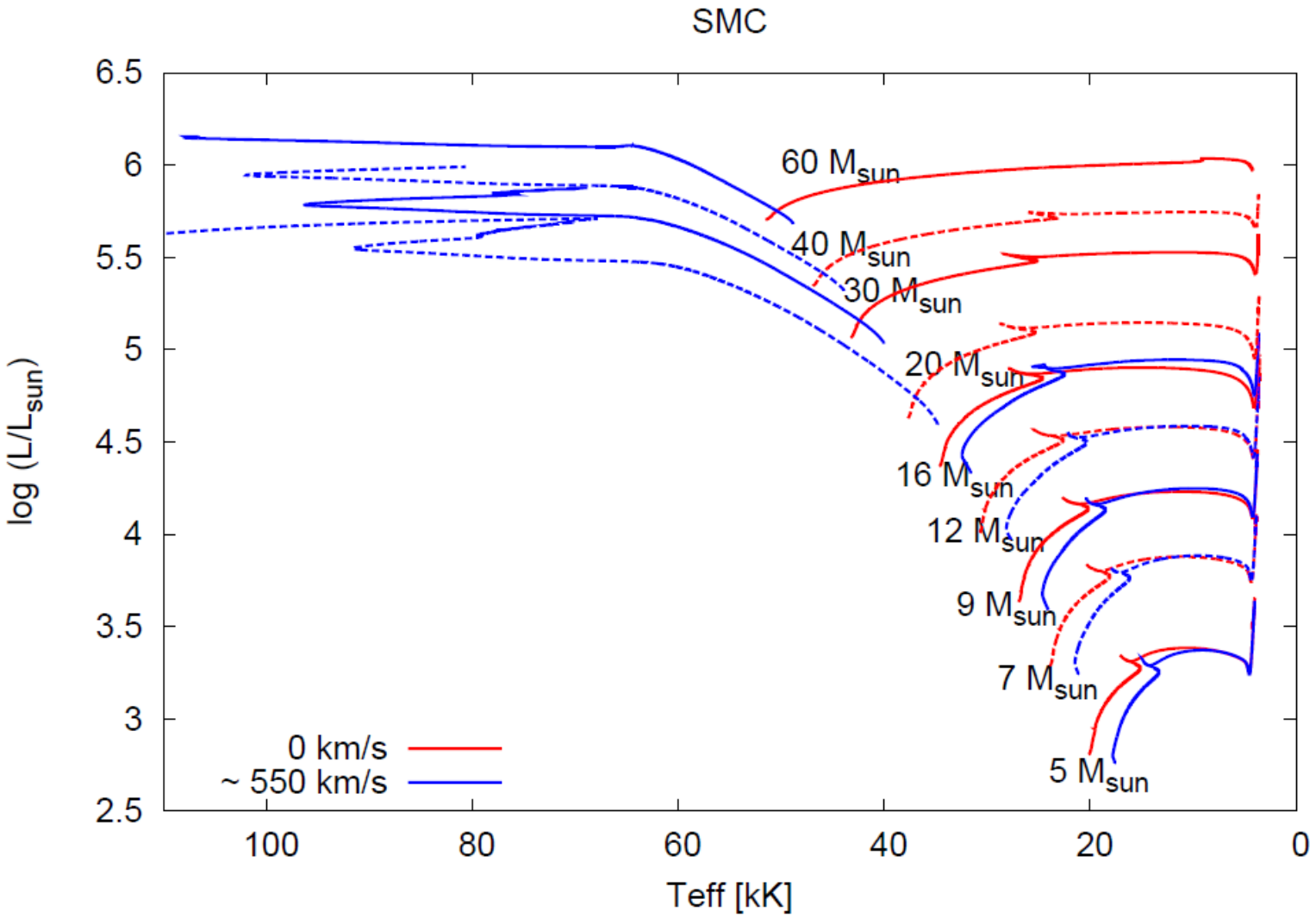
t = 0.00 d

- Common envelope simulation lasts ~few orbital periods
- Unbinds only ~8% of the envelope, although expected to unbind everything



Ohlmann et al. (2016)

Chemically-homogeneous evolution



Brotts et al. (2011)

Why do homogeneous stars evolve bluewards?

$$R \propto \mu^{2/3} M^{0.81}$$ with homology relation and CNO cycle

$$L \propto \frac{\mu^{7.5} M^{5.5}}{R^{0.5}}$$ with homology relation and Kramer's opacity law

$\longrightarrow$ $T_{\rm eff} \propto \mu^{1.5} M^{0.75}$

Yoon's presentation at Carnegie