Differences from single star evolution?

Common envelope
↑ unstable
Mass transfer → stable
↑
loss of angular mom. from binary
(grav. waves or magnetic braking)
tides → influences rotation
→ widen/shrink orbit
→ circularize (heat a star)

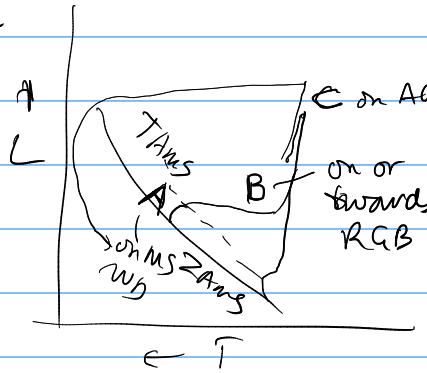
B
"slam a companion"

SN → unbind binary?
pollute the companion

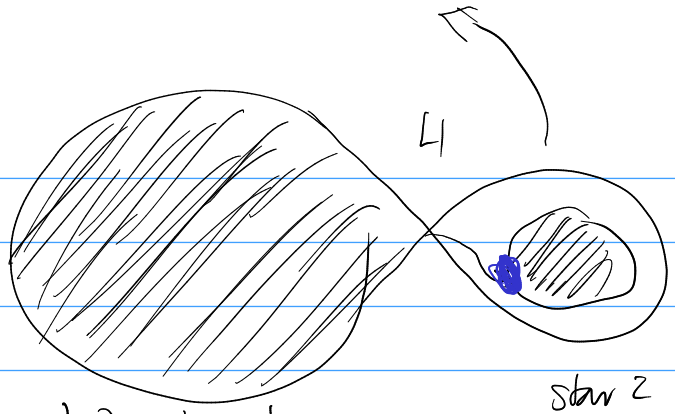
When we would get mass transfer
→ shrink orbit (must have short P to start with)
→ expand your star

↓
Which star? → more massive one

When? → on way to red giant
most likely



Transfer mass
→ what happens?



$\dot{m} = -\dot{M}_1 = +\dot{M}_2$

(conservative mass transfer)

$M_1 \rightarrow \frac{dm}{dt} \rightarrow M_2$

angular momentum

energy? no, lose too much, hard to calculate

$$L = \frac{M_1 M_2}{M_1 + M_2} \sqrt{G (M_1 + M_2) a} = \frac{M_1 M_2}{M} \sqrt{G M a}$$

$$\frac{\dot{L}}{L} = \frac{\dot{M}_1}{M_1} + \frac{\dot{M}_2}{M_2} + \frac{1}{2}\frac{\dot{a}}{a} = 0$$

$$\frac{\dot{a}}{a} = 2 \frac{\dot{m} (M_2 - M_1)}{M_1 M_2}$$

orbit shrinks if $M_1 > M_2$
from more massive to less massive

Stable ① look at Roche lobe $\frac{R_L}{a} = f(q)$

$\Rightarrow$ shrinks faster (L_1 moves in)

② look at stellar radius

I. initially a little smaller

II or HE (dynamescale) expand a little but still smaller than before

III If convective envelope or turnover time back to original radius or a bit bigger

↓

unstable on conv. turnover time → fast, ~ dynamical

III If radiative env. on thermal timescale back to original radius

↓

unstable on thermal timescale

Dynamically unstable

What happens? Common envelope

~ merger

If stars are similar (both MS, 2 WD, etc)

→ proper merger →

rapidly rotating remnant

differentially → magnetic field

Some mass loss → ~ 1% (from simulations)

If one or both are giants

→ can eject the envelope

end w/ binary core (!)

Appeal to basic energetics

(assume fast, not much en. con)

Before $E_{tot,initial} = -\frac{G M_{1,i} M_2}{2 a_i}$

After $E_{tot,final} = -\frac{G M_{1,core} M_2}{2 a_f}$

Eject envelope $E_{env} = -\frac{G M_{1,initial} M_{1,env}}{\lambda R_{1,initial}}$

Assume efficiency $\alpha_{CE} = \frac{E_{env}}{E_{orb,f} - E_{orb,i}}$

$$\frac{a_f}{a_i} = \frac{M_{1,f}}{M_{1,i}} \left[1 - \frac{2}{\alpha_{CE} \lambda} \frac{a_{1,i}}{R_{1,i}} \frac{M_{1,i} M_{1,env}}{M_2} \right]^{-1}$$

↑ if Roche-lobe filling
⇒ f(q)