



Why Do Stars Become Red Supergiants?

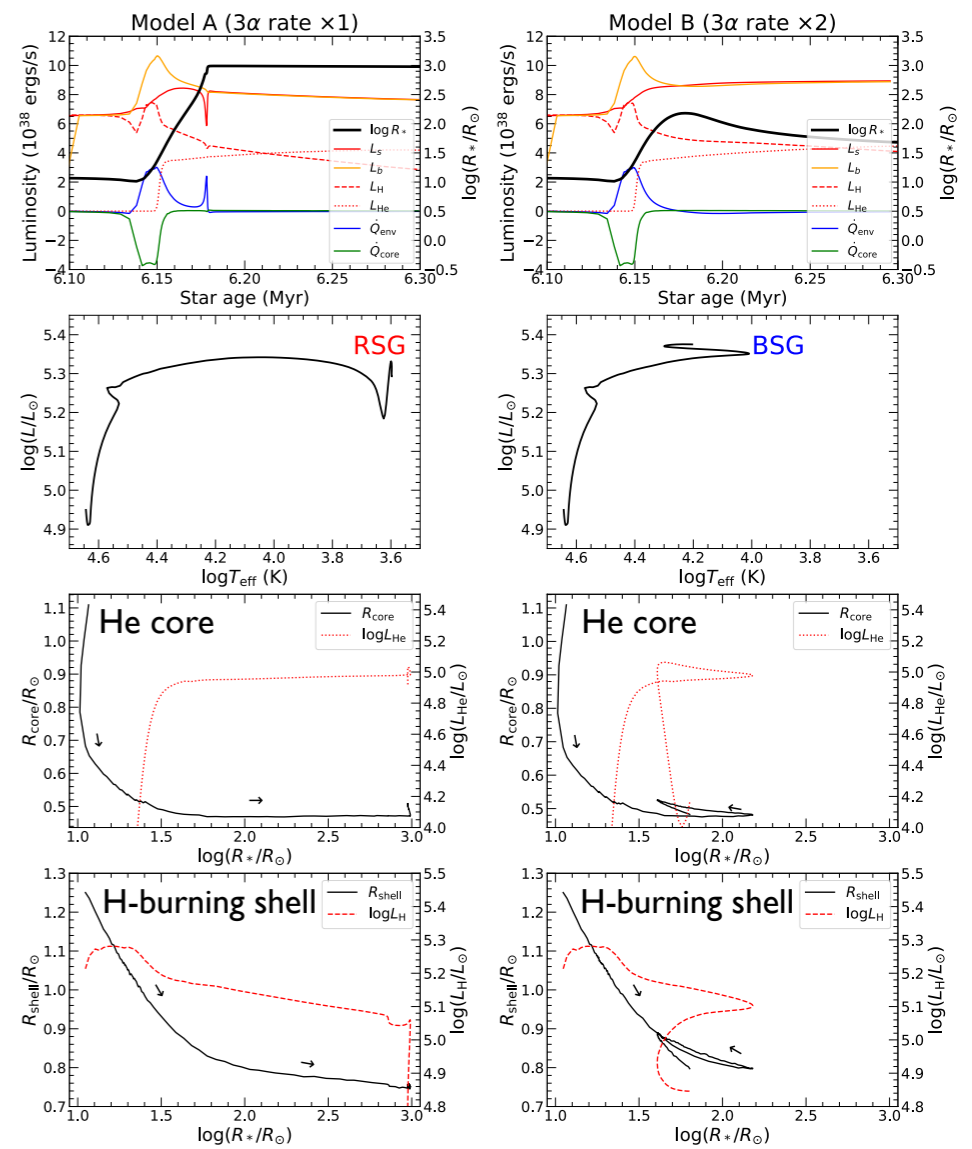
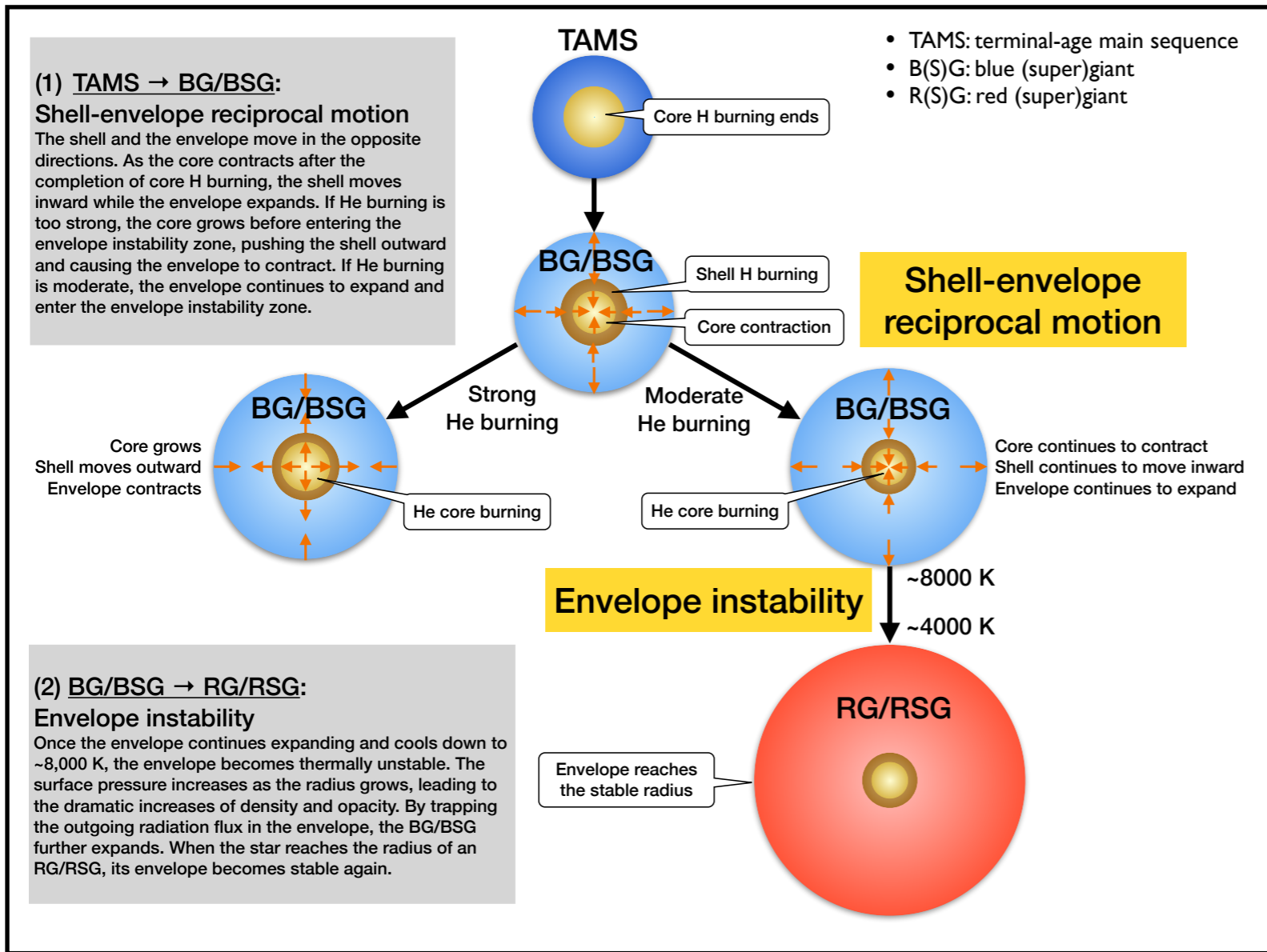


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Stellar evolution (MESA models)

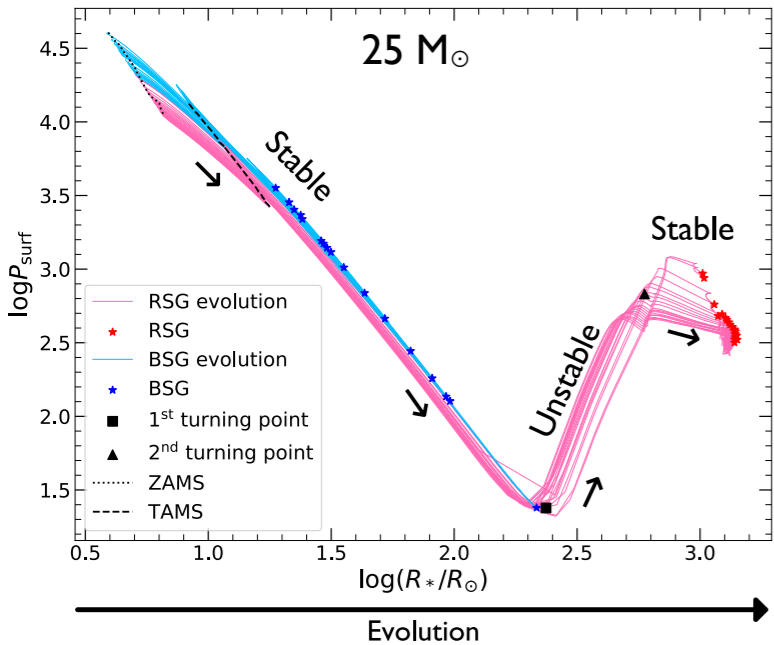


Shell-envelope reciprocal motion

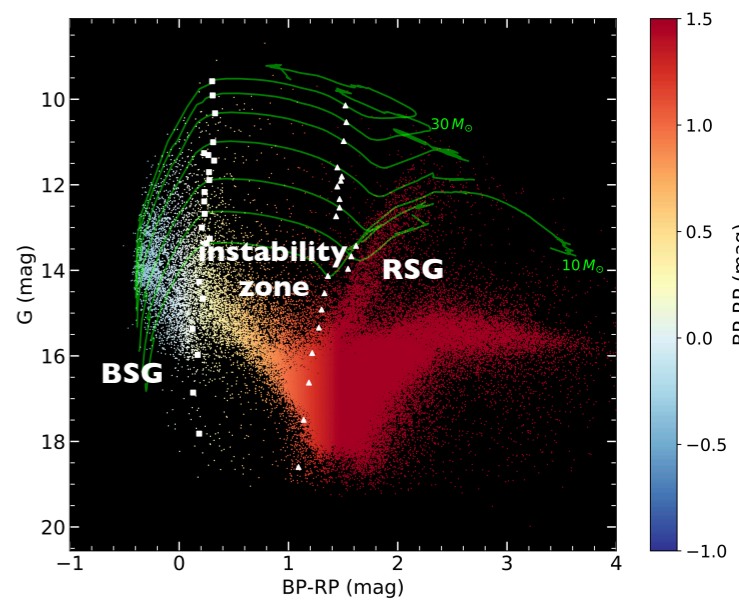
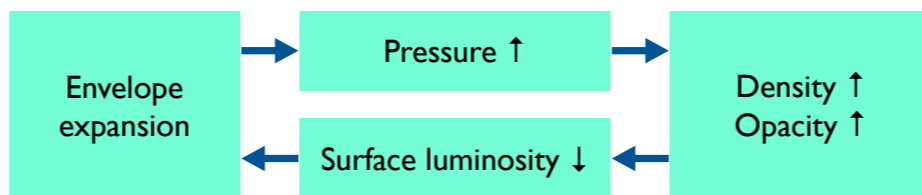
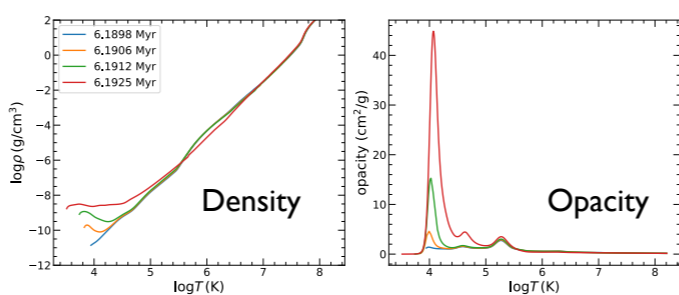
R_{core} : radius of He-burning core
 R_{shell} : radius of H-burning shell
 L_s : surface luminosity
 L_b : envelope base luminosity
 L_H : energy generation rate from H-burning
 L_{He} : energy generation rate from He-burning

Question: Why do (super)giant stars evolve from blue to red?

Answer: Continued expansion due to envelope instability.



Entering the instability zone:



Color-magnitude diagram of the LMC using Gaia DR2 data [White symbols: boundaries of the envelope instability zone for different stellar masses]

Steady-state solutions (simple models using the shooting method)

Question: Why is red (super)giant a common/steady phase in stellar evolution?

Answer: Red (super)giant is a steady-state solution.

Problem setting

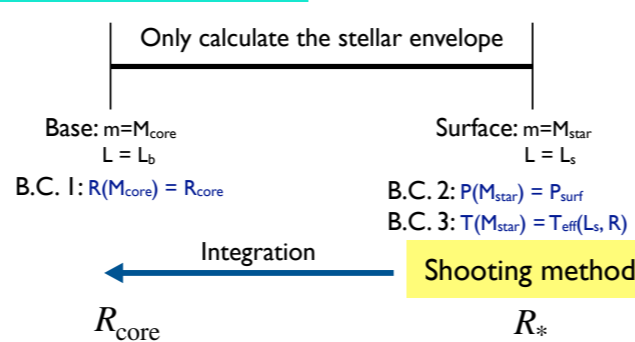
Mass conservation $\frac{dr}{dm} = \frac{1}{4\pi r^2 \rho}$

Hydrostatic equilibrium $\frac{dP}{dm} = -\frac{Gm}{4\pi r^4}$

Energy transport $\frac{dT}{dm} = -\frac{GmT}{4\pi r^4 P} \nabla$

+ opacity table & EOS table (from MESA)

Given R_{core} , what is R_* ?



Solution (25 Msun star with a 7 Msun core)

