The Main Sequence

Solar telescope

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Types of Stars

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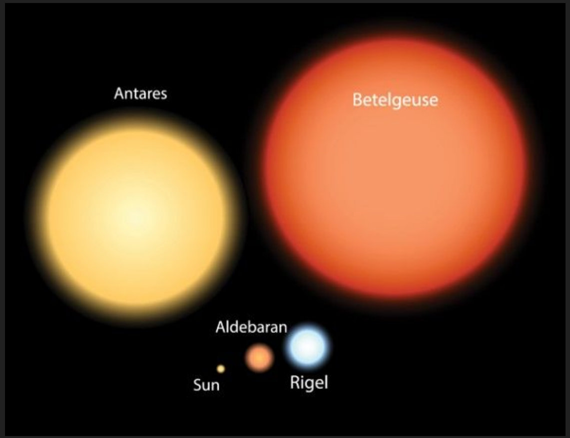
- A star's evolution depends on its mass
- More mass, burns hotter, bluer color
- Divide stars into three categories:
    - Red dwarf
    - Low-to-intermediate mass
    - High mass
- A star's position on the HR diagram tells us which stage of evolution a star is currently in



Types of Stars—Red dwarf

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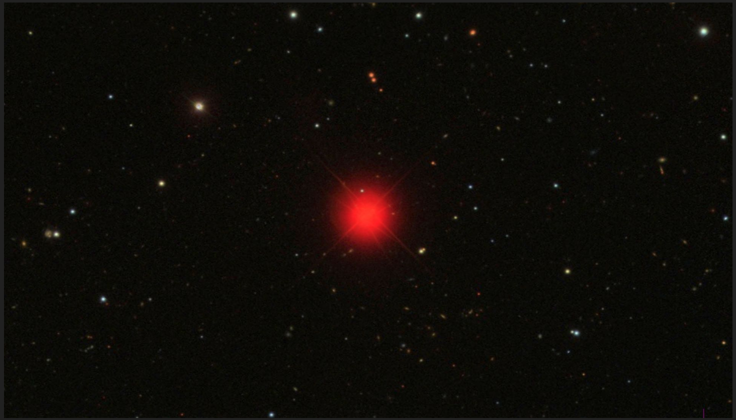
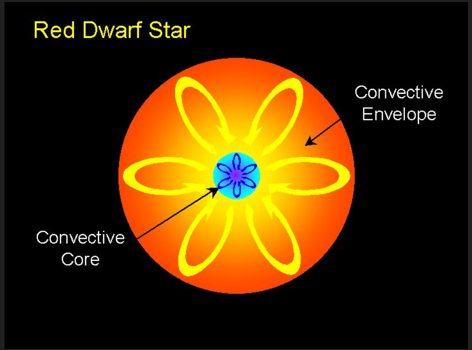
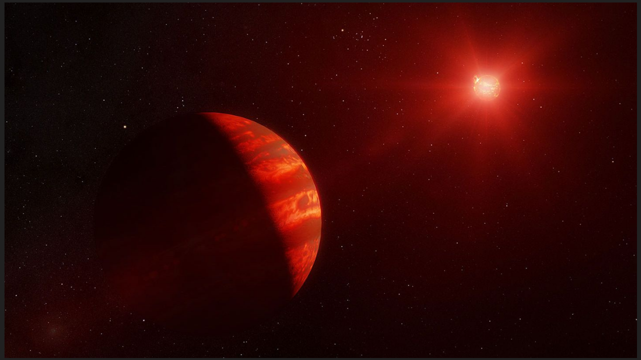
- $0.08\ M_{\odot} < M_{*} < 0.4\ M_{\odot}$
- Fully convective interior (no radiative zone)
- Strong variable magnetic fields
- Live 100s of billions of years
- No red dwarf stars have died yet







Types of Stars—Low-to-intermediate mass

- $0.4\ M_{\odot} < M_{*} < 8\ M_{\odot}$
- Radiative core, convective envelope (low-mass), reverse for intermediate mass
- Magnetic fields (low-mass)
- Live ~10 billion year (low-mass) to ~10 million years (high-mass)
- End their lives as white dwarfs

Types of Stars—High mass

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- $8\,M_\odot < M_* < \sim100\,M_\odot$
- Fully convective core, radiative envelope
- No magnetic fields
- Strong stellar winds
- Live only a few million years
- End their lives with supernova explosions
- Become neutron stars or black holes

Types of Stars—High mass

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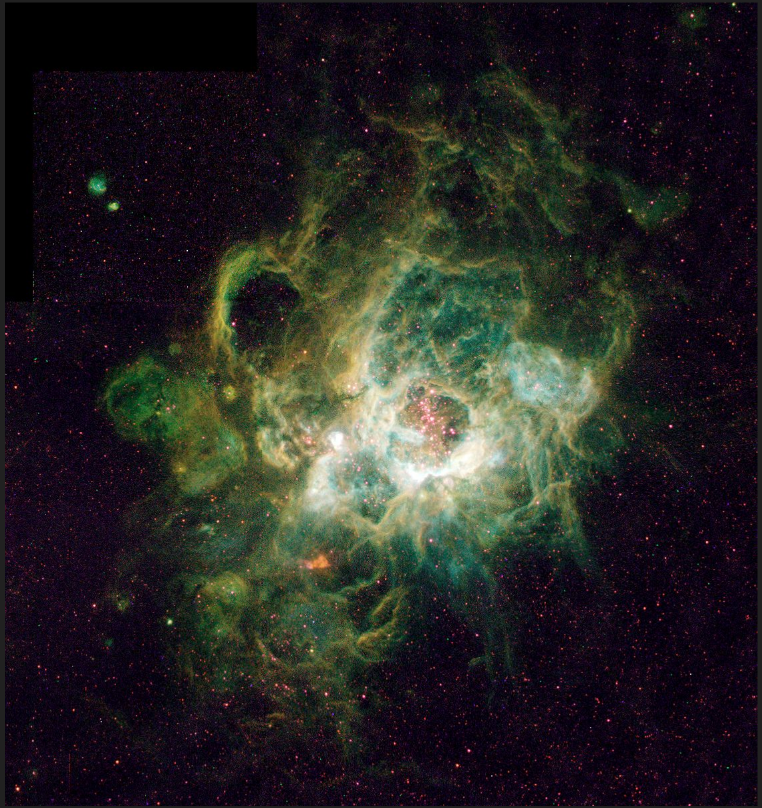
- Stellar winds collide with, heat, ionize surrounding material
- HII regions



Types of Stars—High mass

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Types of Stars—High mass

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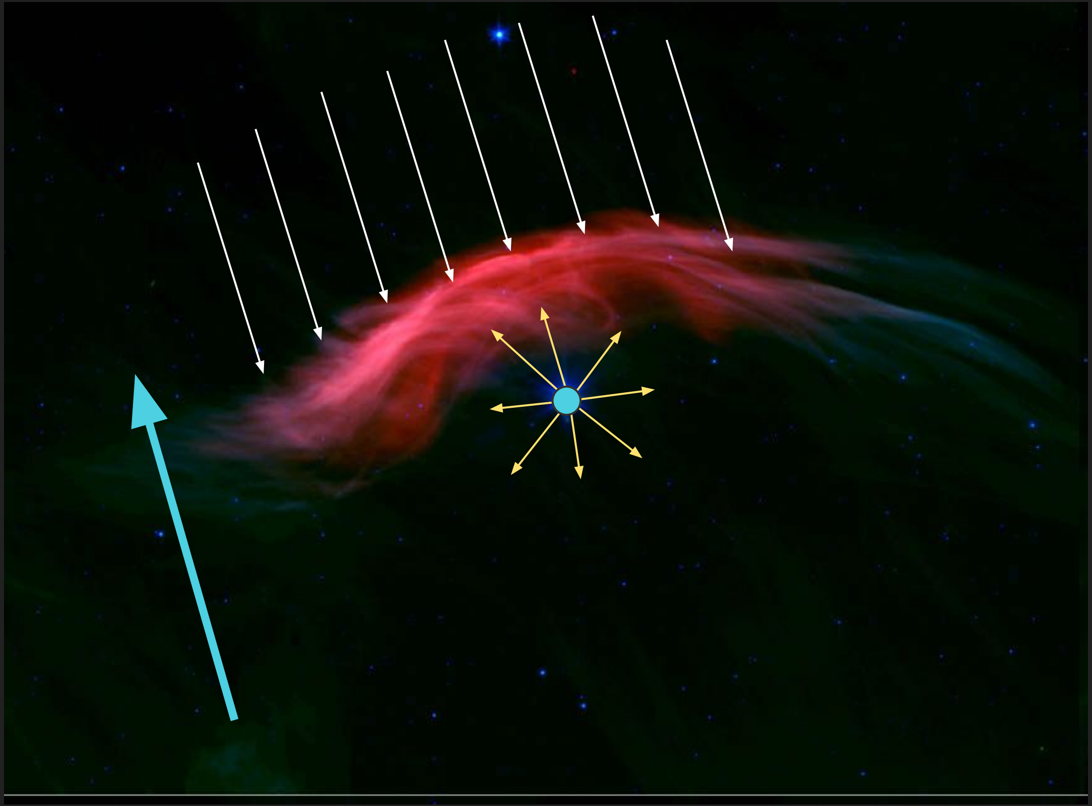
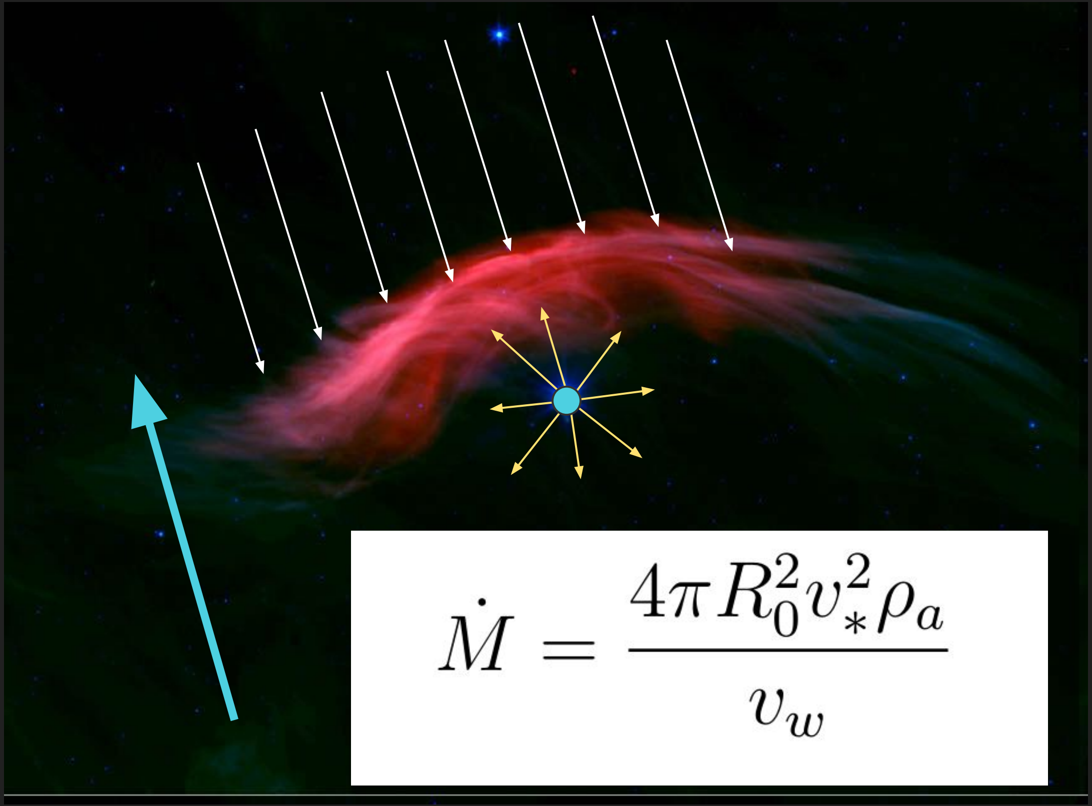
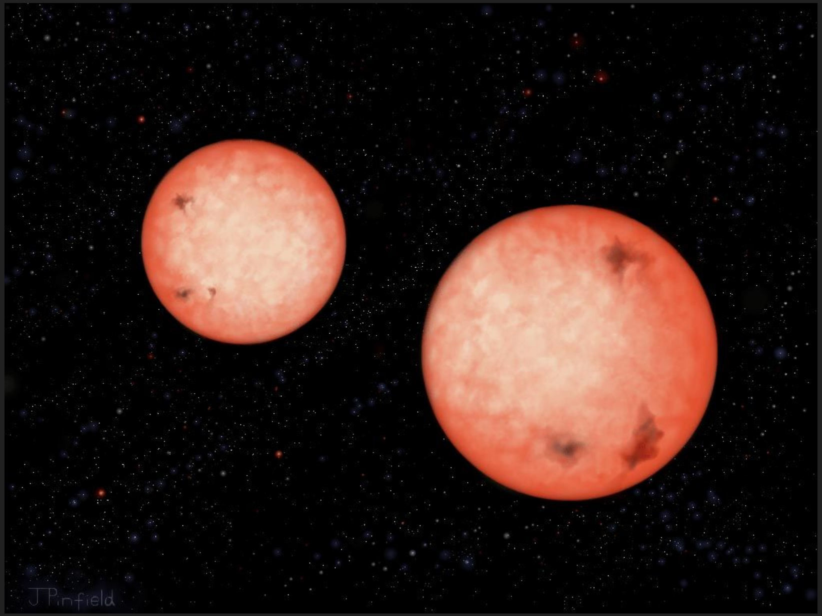


Types of Stars—High mass

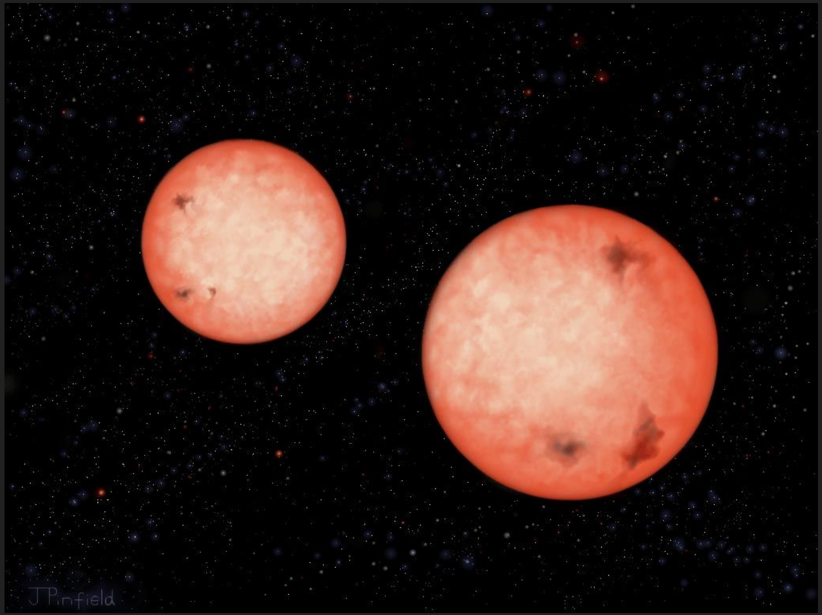


$$\dot{M} = \frac{4\pi R_0^2 v_*^2 \rho_a}{v_w}$$

Main sequence scaling relations



Main sequence scaling relations



Main sequence scaling relations

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Main sequence scaling relations

Main sequence scaling relations

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- Mass is correlated with temperature, luminosity, radius
- Hotter stars burn brighter, live shorter lives
- Cooler stars burn dimmer, live longer lives
- “Live fast, die young”

$$\tau_{\mathrm{MS}} \propto \frac{M_*}{L_*}$$

$$L_* \propto M_*^{3.5}$$

$$\tau_{\mathrm{MS}} \propto \frac{M_*}{M_*^{3.5}}$$

$$\tau_{\mathrm{MS}} \propto M_*^{-2.5}$$

$$\tau_\odot \approx 10^{10} \text{ years}$$

$$\boxed{\tau_{\mathrm{MS}} = 10^{10}\left[\frac{M}{M_\odot}\right]^{-2.5} \quad (\text{for } 0.1 \lesssim M_* \lesssim 50)}$$

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$$\frac{L}{L_\odot} = \left[\frac{M}{M_\odot}\right]^{3.5}$$

$$\tau_{\mathrm{MS}} = 10^{10}\left[\frac{M}{M_\odot}\right]^{-2.5}$$

Announcements

- Homework 6 due Friday
- No lab next week

Next time

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- The Death of Stars I