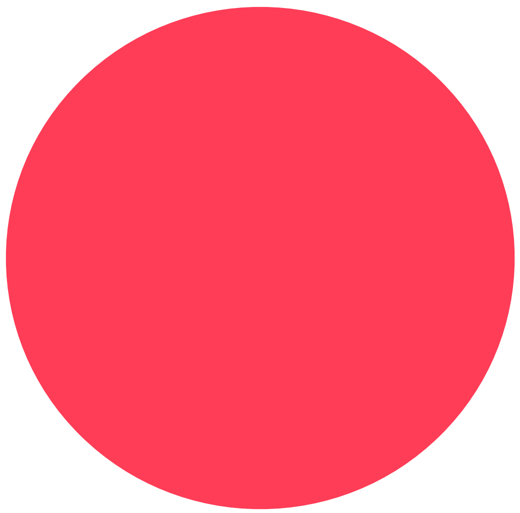
how stars work

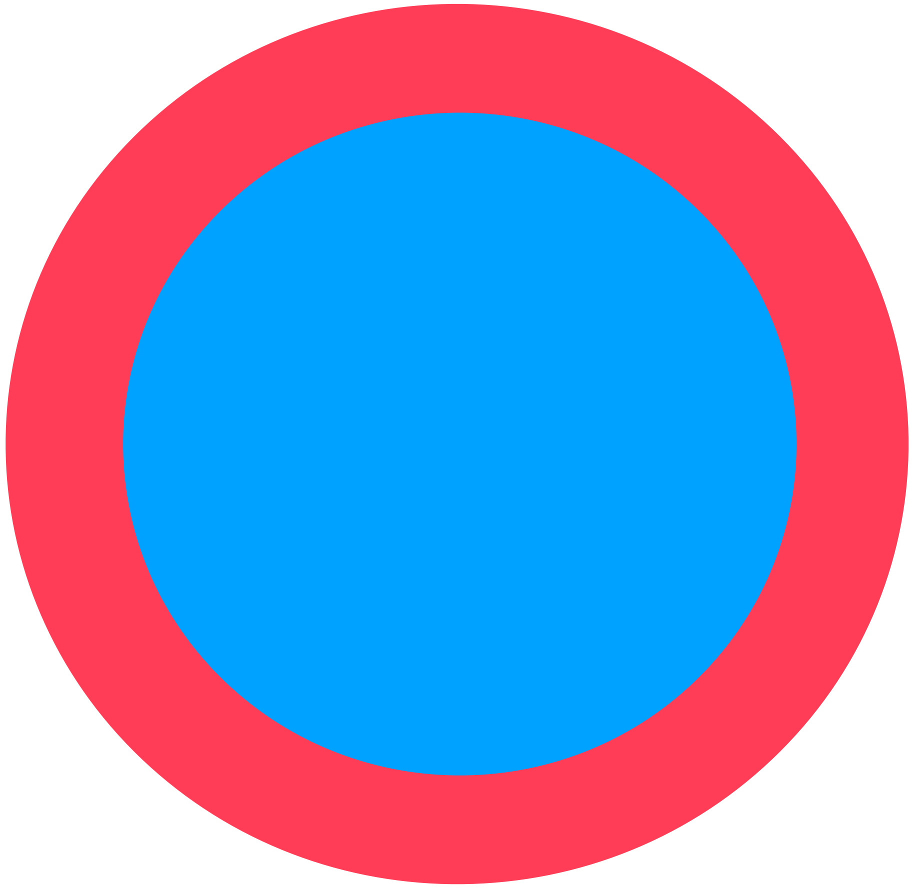
simple picture: a star is

- a spherical ball of gas
- in hydrostatic equilibrium



reasons: appearance at sunrise, sunset; energy input to Earth what stops the Sun from collapsing under gravity?

gas pressure increases inwards



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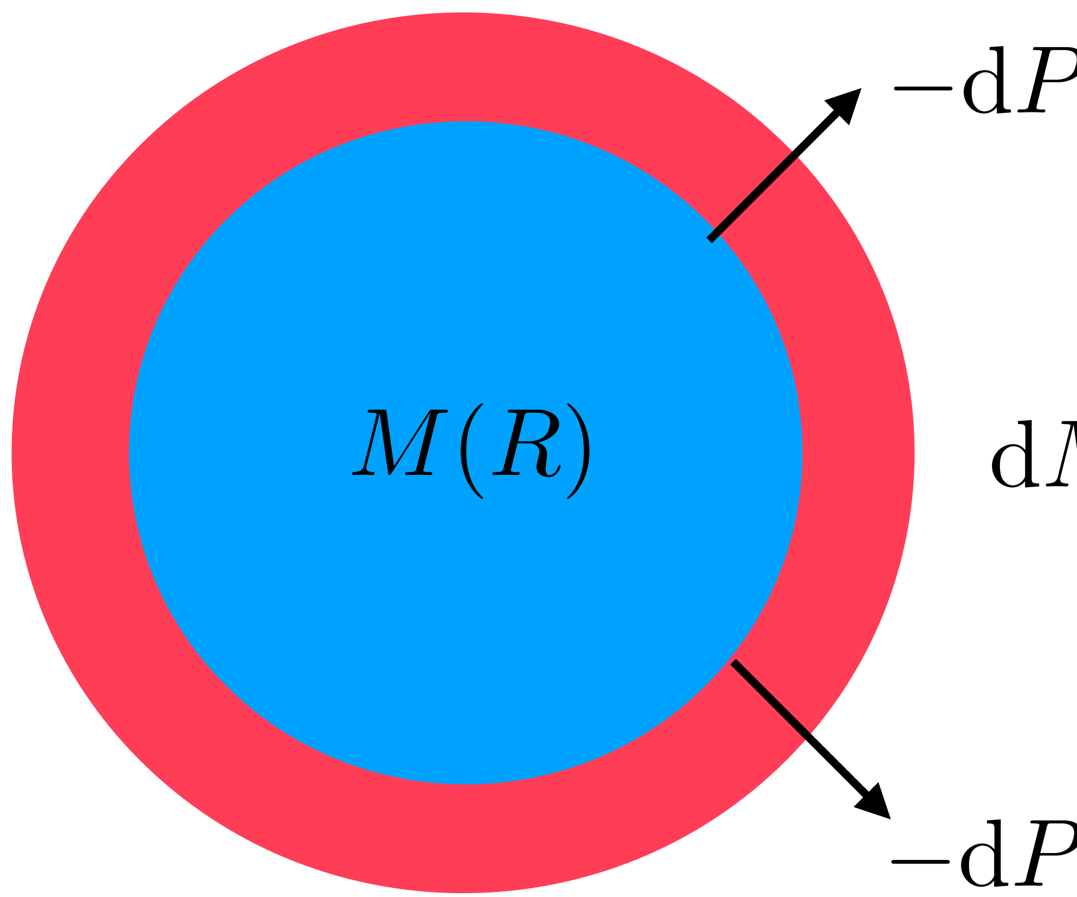

$$\mathrm{d}M(R) = 4\pi\rho R^2 \mathrm{d}R$$

$\rho =$ density

$$-\mathrm{d}P = \frac{GM(R)\mathrm{d}M}{R^2}$$

so

$$\frac{\mathrm{d}P}{\mathrm{d}R} = -\frac{GM(R)\rho}{R^2}$$

with

$$M(R) = 4\pi \int_0^R \rho r^2 \mathrm{d}r$$

and

$$P = \frac{\rho k T}{\mu m_H}$$

with $T =$ temperature, $k/\mu m_H =$ `gas constant'

In principle we need equations describing energy generation and transport etc to solve stellar structure…….

but *simple approximations give a lot of insight*:

estimate

$$\frac{\mathrm{d}P}{\mathrm{d}R} \sim \frac{P_c}{R_*}$$

and $$M(R) \sim M_*$$

where M_*, R_* are the star's mass and radius, and $P_c = \dfrac{\rho_* kT}{\mu m_H}$

is its central pressure, with ρ_* the central density:

then

$$T_c \sim \frac{GM_* \mu m_H}{kR_*} \sim 10^7 \frac{M_*}{M_\odot} \frac{R_\odot}{R_*} \,\mathrm{K}$$

(we know $GM_\odot$ from planetary orbits, and $R_\odot$ from e.g. solar luminosity and spectroscopic measurement of solar *surface* temperature) what is the significance of this?

10^7 K allows hydrogen nuclei to approach each other closely enough that strong nuclear force can fuse then to make helium

this is the energy source for most stars - the `main sequence'

can deduce that such stars always have radii such that their central temperatures are 10^7 K

so

$$\frac{R_*}{R_\odot} \sim \frac{M_*}{M_\odot}$$

for stars which have evolved off the main sequence

$$\frac{\mathrm{d}P}{\mathrm{d}R} \sim \frac{P_c}{R_*}$$

is NOT a good approximation: *core-envelope structure*