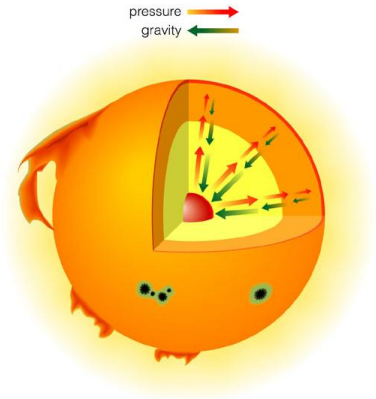
Star's life: Protracted battle with gravity



ALWAYS

To support weight:

⇒ need high pressure

MOSTLY

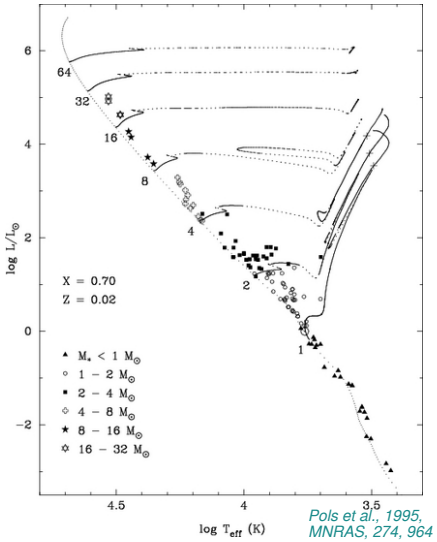
⇒ need high temperature

⇒ will loose energy

⇒ need energy source:
- Gravitational contraction
- Nuclear fusion

Ultimately,
Can something else than thermal pressure balance gravity?

Evolutionary tracks:
what happens depends on mass



Pols et al., 1995, MNRAS, 274, 964

Distance	$d\,[pc] = 1/\pi\,[arcsec]$
magnitudes	$m = C - 2.5 \log f$; $m_1 - m_2 = -2.5 \log(f_1/f_2)$; $M - m = 5 - 5 \log d$
Doppler shift	$\frac{\Delta\lambda}{\lambda} = \frac{v_{rad}}{c}$
Gravity & tides	$a = \frac{GM}{r^2}$; $a_{tide} \approx \frac{GM}{r^2}\frac{2R}{r}$
Kepler	$GM = \Omega^2 a^3 = \left(\frac{2\pi}{P}\right)^2 a^3$; $\frac{a_1}{a} = \frac{v_1}{v} = \frac{m_2}{M}$; for circular orbit, $v = \sqrt{\frac{GM}{a}}$
Virial Theorem	$E_{kin} = -\frac{1}{2}E_{pot}$; $E_{tot} = E_{kin} + E_{pot} = \frac{1}{2}E_{pot}$ [where $E_{pot,bin} = -\frac{GM_1M_2}{a}$ and $E_{pot,star} \approx -\frac{GM^2}{R}$]
Ideal gas	$P = nkT = \frac{\rho}{\mu m_H}kT$; typical kin. en. per particle $\langle e \rangle = \frac{3}{2}kT$; en. density $e = \frac{3}{2}nkT = \frac{2}{3}P$
Degenerate gas	$\Delta x \Delta p \sim \hbar$; $E_F = \frac{1}{2}\frac{p_F^2}{m_e} \propto n_e^{2/3}$; $P \propto n_e E_F \propto n_e^{5/3} \propto (\rho/\mu)^{5/3} \rightarrow R \propto M^{-1/3}$
Photon propagation	$l_{mfp} = 1/\sigma n = 1/\kappa\rho$; $t_{random} = \frac{R}{l_{mfp}}\frac{R}{c}$
Black body	$L = 4\pi R^2 \sigma T_{eff}^4$; $\lambda_{peak} \propto 1/T$
Hydrostatic eq.	$\frac{dP}{dr} = -\rho\frac{GM}{r^2}$; → $P \propto M^2/R^4$
Radiative transfer	$\frac{dT}{dr} = \frac{3\kappa\rho}{16\sigma T^3}\frac{L_r}{4\pi r^2}$; → $L \propto T_c^4 R^2 \frac{l_{mfp}}{R}$
Timescales	$\tau_{ff} \sim \sqrt{\frac{r^3}{GM}} \sim \sqrt{\frac{1}{G\rho}}$; $\tau_{KH} \sim \frac{GM^2/R}{L}$
Hydrogen fusion	$E = mc^2$; p-p start with $p + p \rightarrow D + e^+ + \nu_e$; CNO catalyst, start with $^{12}C + p \rightarrow {}^{13}N + \gamma$
Hydrogen atom	$E_n = -13.6eV/n^2$