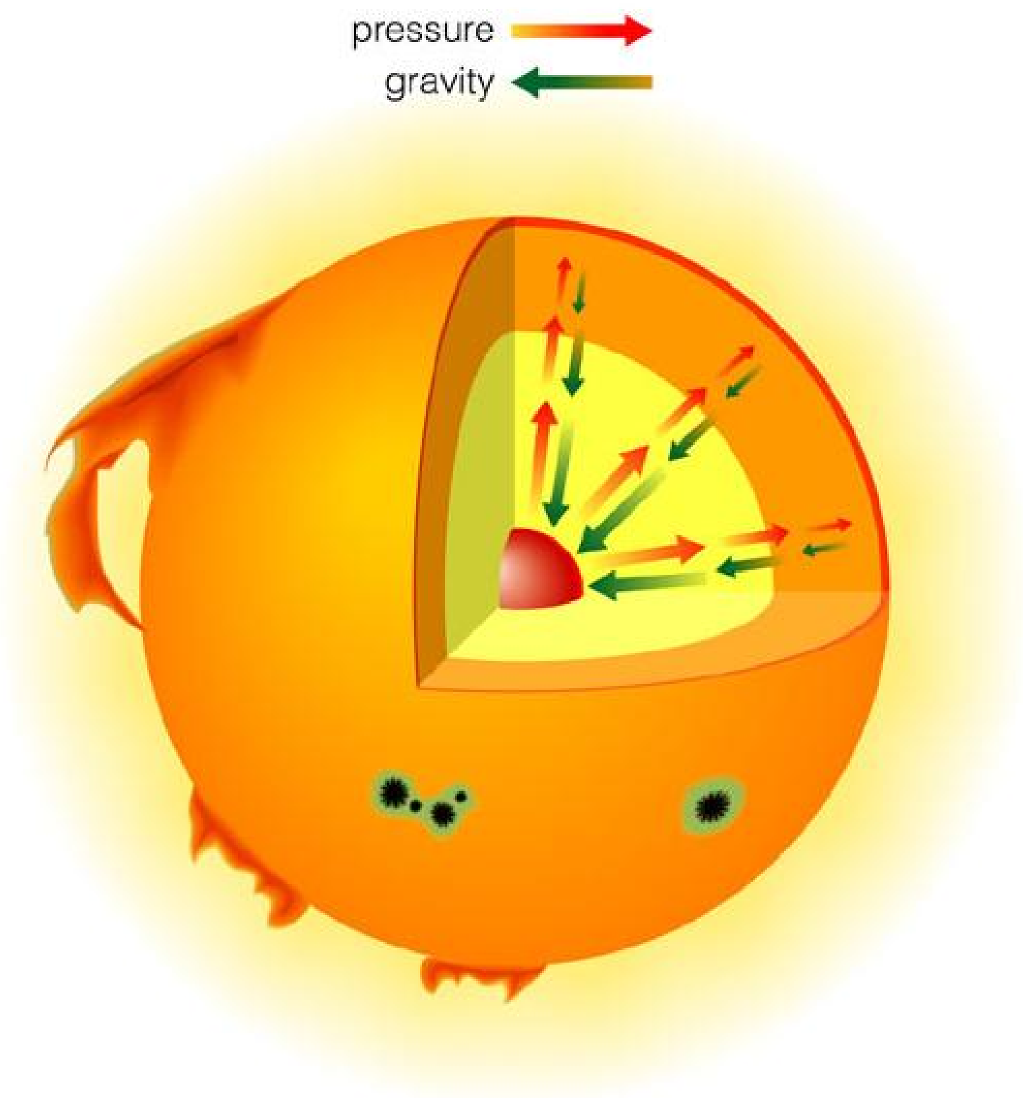
Star's life: Protracted battle with gravity



ALWAYS

To support weight:

⇒ need high pressure

MOSTLY

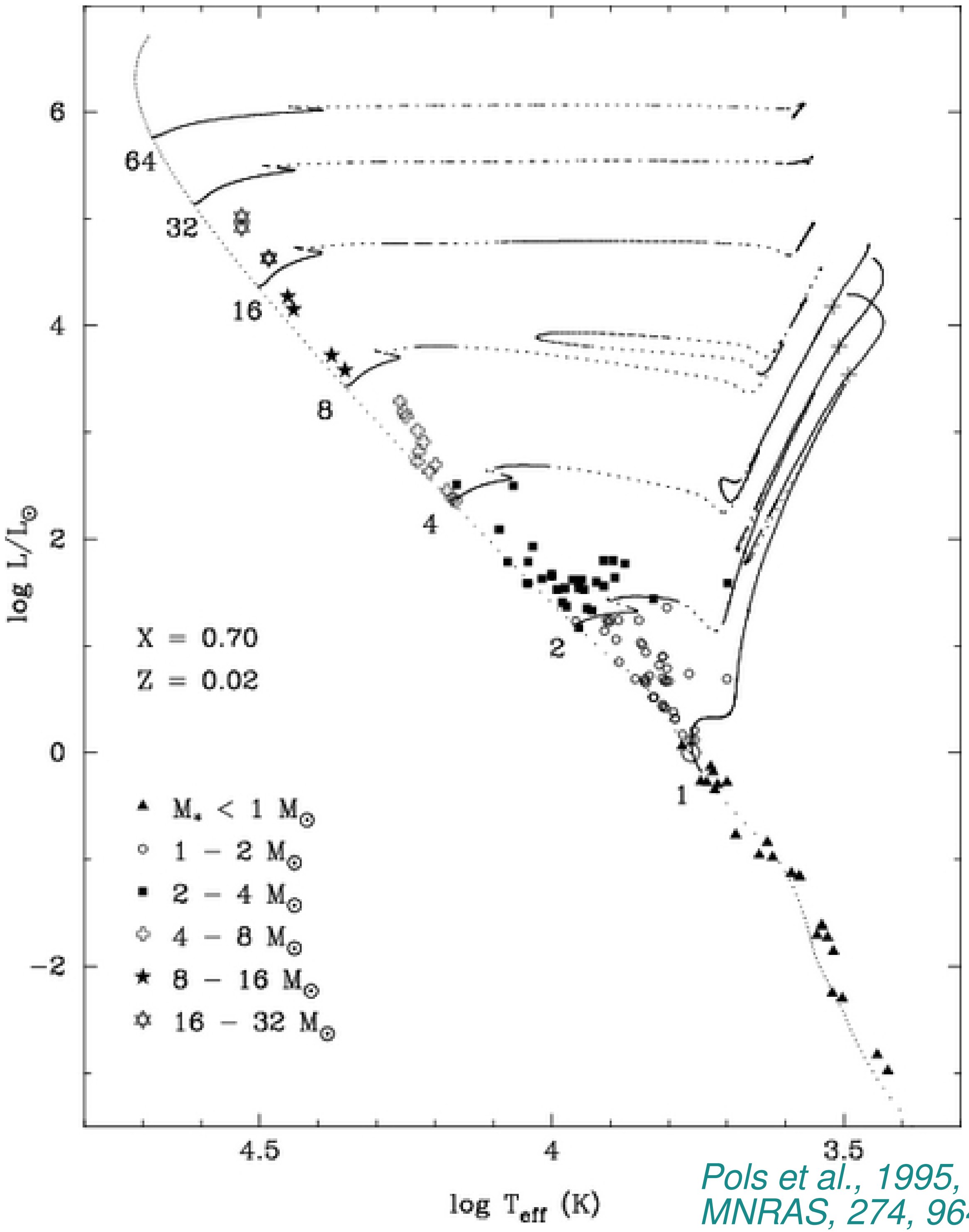
⇒ need high temperature

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