Degenerate objects : e^- deg $\Rightarrow$ causes a pressure much larger than the thermal pressure

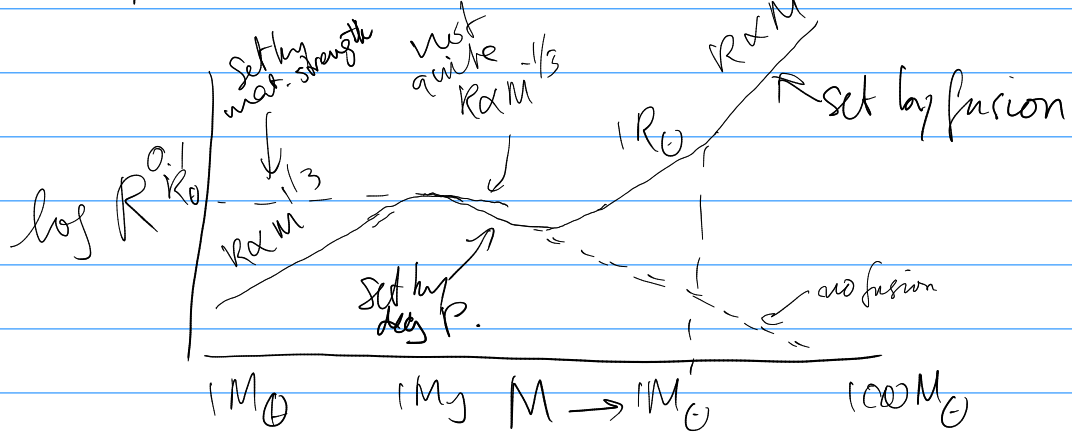
Non-rel. $P_{NRED} = K_1 (\rho/\mu_e)^{5/3} \Rightarrow n = 1.5$ polytrope

extr. rel. $P_{ERED} = K_2 (\rho/\mu_e)^{4/3} \Rightarrow n = 3$ polytrope

HE: $P \approx \frac{GM^2}{R^4}$, MC $\rho \approx \frac{M}{R^3}$

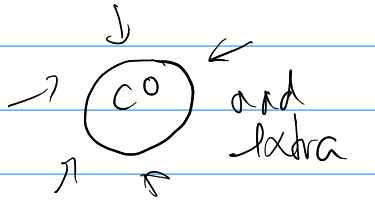
NR $P \propto \rho^{5/3}$

$$\frac{M^{5/3}}{R^5} \propto \frac{M^2}{R^4} \Rightarrow R \propto M^{-1/3}$$



ER $P \propto \rho^{4/3} \Rightarrow \frac{M^{4/3}}{R^4} \propto \frac{M^2}{R^4} \Rightarrow M = \text{constant}$

Virial Th.: $E_{KIN} = -E_{POT} \Rightarrow E_{TOT} = E_{POT} + E_{KIN} = 0$



$M \uparrow \Rightarrow$ pressure needed to support star $\uparrow$

$\rightarrow$ Shrink $\rightarrow \rho \uparrow \Rightarrow P_F \uparrow \Rightarrow P_{deg} \uparrow$

net $R \propto M^{-1/3}$

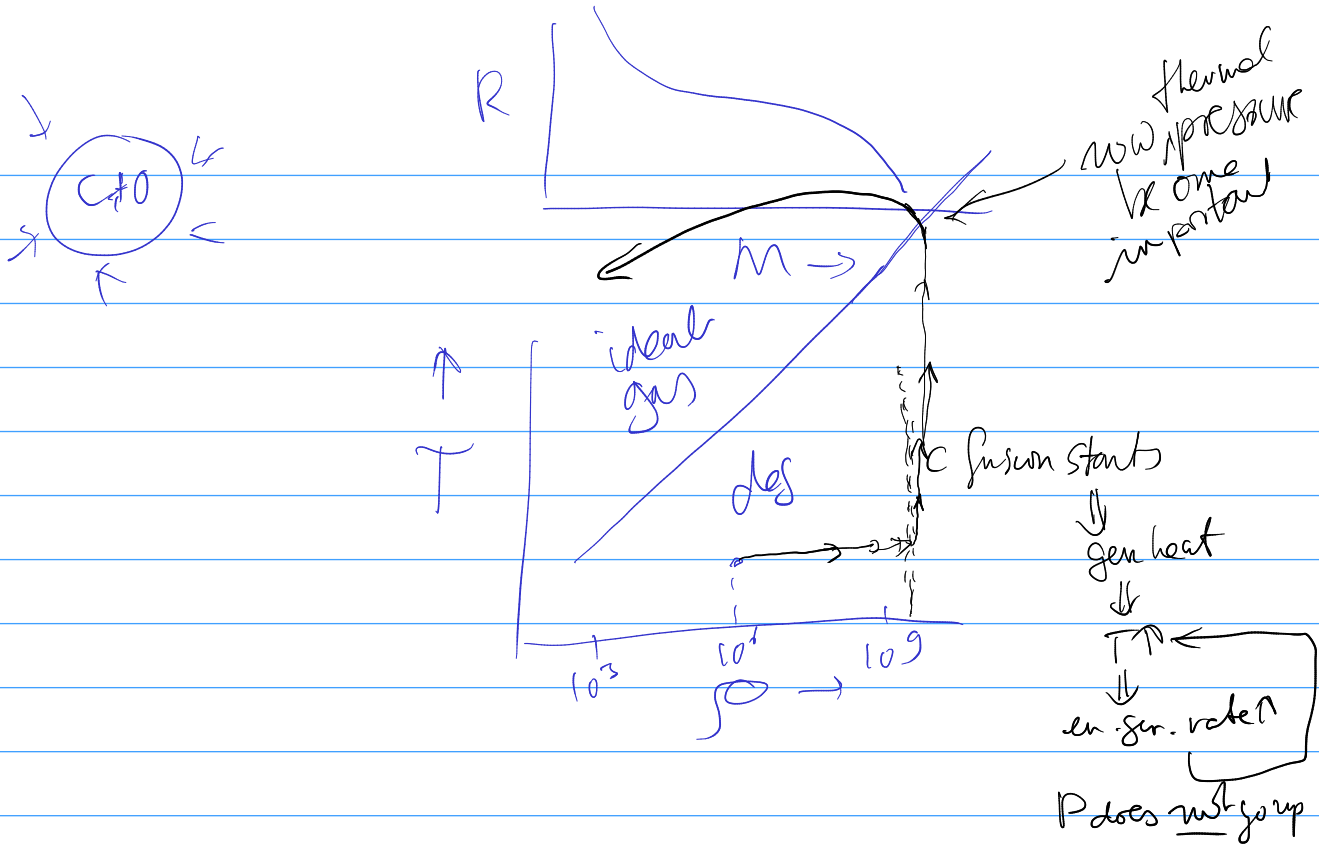
goes on until $v_e \rightarrow c$, $M = M_{ch}$

$\Rightarrow$ collapse to NR outer parts

Reality: nucleons get close together too $\rightarrow$ start fusing (if C or He)

e^- very energetic $\rightarrow$ inverse β decay ${}^{A}_{Z}N + e^- \rightarrow {}^{A}_{Z-1}N + \nu_e$

(ONeMg WD) $\longrightarrow$ collapse $\rightarrow$ Neutron star (e^- capture SN)


R
M →
thermal
now pressure
is one
important
ideal
gas
T
degs
C fusion starts
gen heat
en. gen. rate↑
P does not go up
10³
10⁶
10⁹
ρ →

Ionisation

Boltzmann $\frac{n_1}{n_2} = \frac{g_1}{g_2} e^{-\Delta E / kT}$

ΔE: energy difference between the two states

g_1, g_2: number of ways one can be in state 1 or 2

Hydrogen $n = 1 \to 2$ $\Delta E = 10.2\,eV \Rightarrow kT \approx 10.2\,eV \Rightarrow T \approx 10^5 K$

ionisation $n = 1 \to \infty$ $\Delta E = \chi = 13.6\,eV \Rightarrow T \approx 10^5 K$ ~~?~~

Stars: $T \approx 10^4 K$

i.s.m

cosmology rec. at $T \approx 3000\,K$

$H^0 (+\gamma) \to p^+ + e^-$

For e^- w/ given p_e $\frac{dn_{r+1}}{n_r} = \frac{g_{r+1}}{g_r} dg(p_e) e^{-(\chi_2 + p_e/2m)/kT}$

$\vdots$

$\int_{p_e}$ $\frac{n_{r+1}}{n_r} = \frac{g_r}{g_{r+1}} 2 \frac{(2\pi m_e kT)^{3/2}}{n_e h^3} e^{-\chi/kT}$

very large number

Also: pair creation

$kT = m_e c^2$?

No, sooner