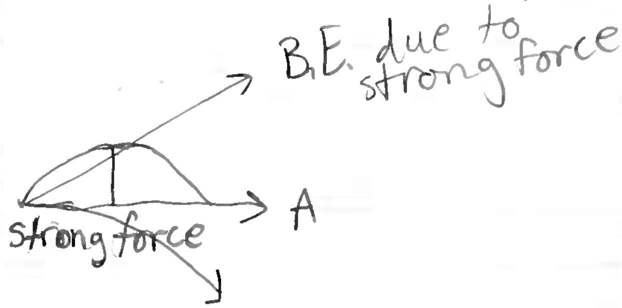
2-16

End of a Star

reason Fe is last element to fuse in core:



$$U_{electricity} = +\frac{3}{5}\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q^2}{R}$$

$$U_{gravity} = -\frac{3}{5}\frac{GM^2}{R}$$

Strong force keeps nucleus together, but the electromagnetic force of the protons repel each other.

Types of Pressure in Star:

① $P_{gas} = \frac{N}{V}\cdot kT$

② $P_{radiation} = \frac{1}{3} u_{rad}$

③ $P_{degeneracy}$ - in the core

After the final collapse, a star becomes a white dwarf. This is the remnant of the co

Binary system of Sirius has a white dwarf.

Sirius

A - $2.02 M_{\odot}$, $25.4 L_{\odot}$, 9,940K, $1.711 R_{\odot}$

B - $1 M_{\odot}$, $0.03 L_{\odot}$, 27,000 K, R=5,500km

Sirius B is very dense! So dense that the distance between atoms is so small that atoms overlap. This means the electrons are not fully attached to nuclei, so white dwarfs are great conductors.

derivative of U_{grav}:

$$\frac{dU_{pot}^{grav}}{dR} = \frac{\frac{3}{5} GM^2}{R^2}$$

Temperature does not create enough pressure to counteract this rate of gravity! Degeneracy Pressure is needed.

Two types of fundemental particles

fermions: e^-, ν, n, p^+... building blocks of atoms

spin ⇒ $\frac{\hbar}{2}$, $\frac{3\hbar}{2}$ pauli principle ✓

bosons: π, γ, Higgs, ... make interactions happen

spin ⇒ 0, $1\hbar$, $2\hbar$ puali principle ×

Pauli principle, can not put more than one fermion into a single quantum state. (spin can allow 2 e^- into the ground state)

So in a white dwarf there are 10^{57} e^-. Since electrons cannot be in the same state, there will be 10^{57} states. This takes up a volume of

$$V_{space} = \frac{4\pi}{3} R^3$$

These electrons can also have different momentum states. The volume in momentum space:

$$V_p = \frac{4\pi}{3} P_{fermi}^3 .$$ The maximum momentum $= P_{fermi}$

$V_s \cdot V_p = h^3$ ← Plank's constant. This means there is a uncertainty principle that fulfills $\Delta x \cdot \Delta p \geq \frac{\hbar}{2}$, $h = 2\pi\hbar$

Degenerate Fermi Gas.

To find the amount of fermions that will fit in a volume:

$$\frac{4\pi}{3} R^3 \cdot \frac{4\pi P_f^3}{3} \Rightarrow \frac{V_{space} \cdot \frac{4\pi P_f^3}{3}}{h^3} \geq \frac{1}{2} N_e$$

Total Kinetic Energy of 10^{57} e^-:

$$E_{kin}^{tot} = \frac{3\hbar}{10 m_e} (3\pi^2)^{1/3} \left(\frac{N_e}{V}\right)^{2/3} N_e$$

This goes up as volume gets smaller. It can counter act the energy of gravity.