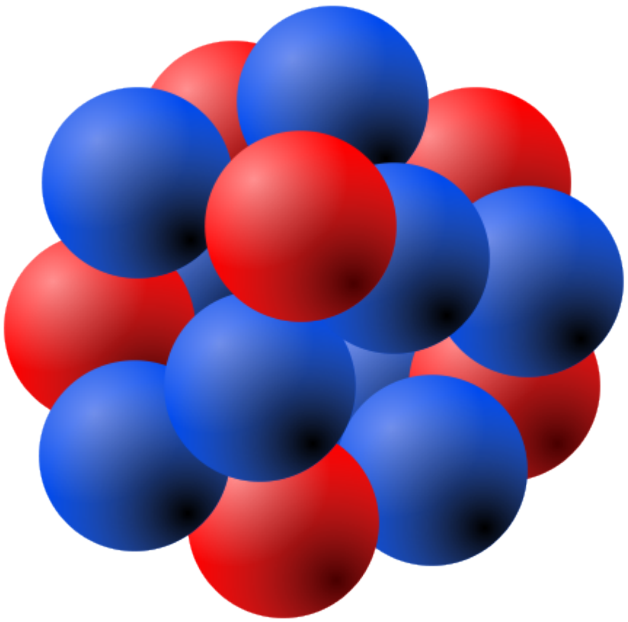
Introductory Astronomy

Week 4: Stars

Clip 2: Nuclear Physics

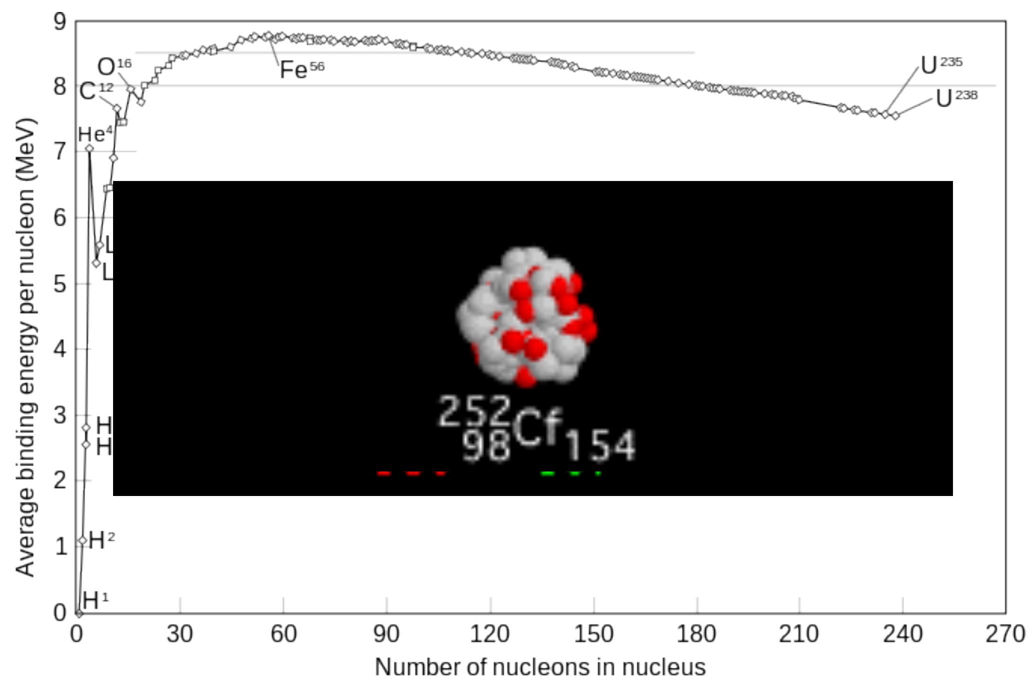
Nuclear Physics

- Why don't nuclei break up under electric repulsion?
- A strong attractive force binds nucleons
- Short-range $\sim 10^{-15}\,\mathrm{m}$ since atoms do not collapse



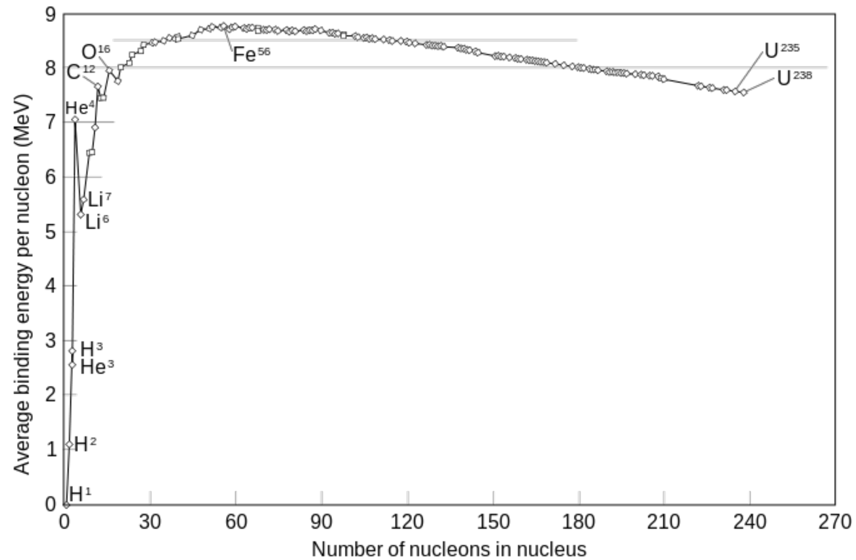
Nuclear Energy

- Rearranging nucleons recover nuclear energy
- In large nuclei distant nucleons barely attract
- Breaking up – fission – or α emission recover electromagnetic energy
- Heats planets powers reactors



Fusion?

- In small nuclei, less attractive interactions
- Liberate nuclear energy by fusion to Helium
- Problem: Hydrogen is all protons
- Strong interactions cannot change a proton to a neutron



Weak Interactions

- Something can do this!
- And the inverse
- A free neutron decays in 15min

$$n \rightarrow p^+ + e^- + \overline{\nu}_e$$

- Weak nuclear force mediates this decay

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Some Questions and Answers

- Can a force change one particle into another?

  Yes

- Is a neutron just a tiny Hydrogen atom? No
- What is $\overline{\nu}_e$?
- Are there any rules?

- Conservation Laws
  - Mass-Energy $E = mc^2$
  - Momentum
  - Angular Momentum
  - Electric Charge
  - Electron Number
- Weak interaction: rare

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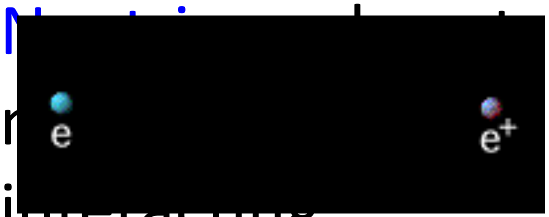
Particle Physics

Particle	Q	N_e
p	1	0
n	0	0
e	-1	1
ν_e	0	1
$\overline{p}^-$	-1	0
$\overline{n}$	0	0
e^+	1	-1
$\overline{\nu}_e$	0	-1
γ	0	0

- Antiparticle: same mass opposite charges
- 

interacting
- Discovered as missing energy in n decay

Credits

- Nuclear Animations: LBL/J. Mattis http://ie.lbl.gov/education/glossary/glossaryf.htm