Stellar Nucleosynthesis

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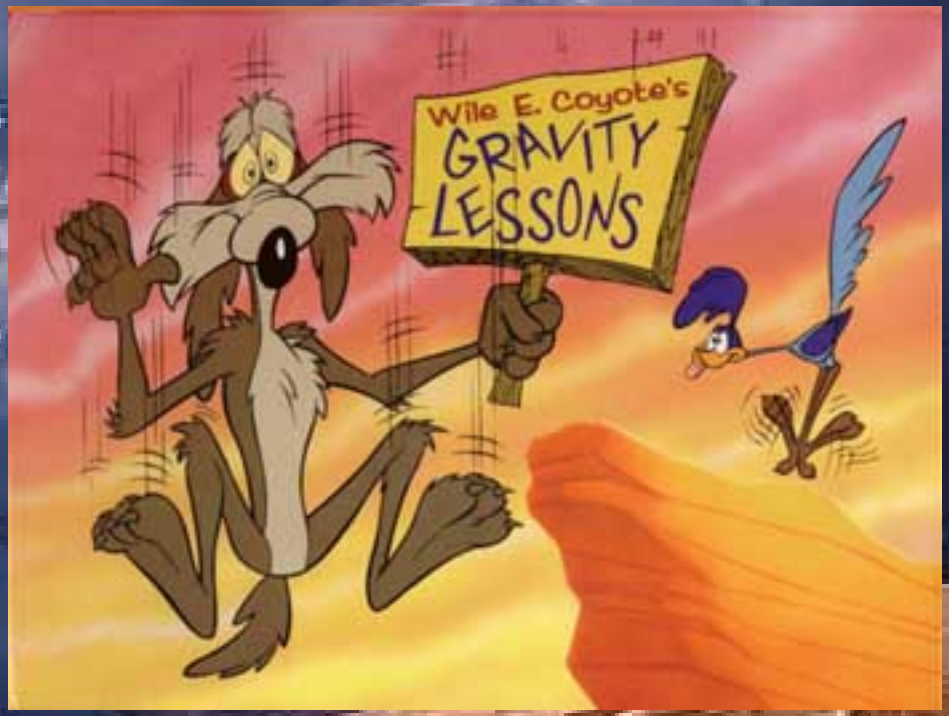
What makes stars shine?

- *FUSION*, the process by which lighter nuclei join to form heavier nuclei, is the process which powers our Sun, and most stars.
- Our Sun is constantly turning hydrogen into helium, with a power output of $4*10^{26}$ Watts.

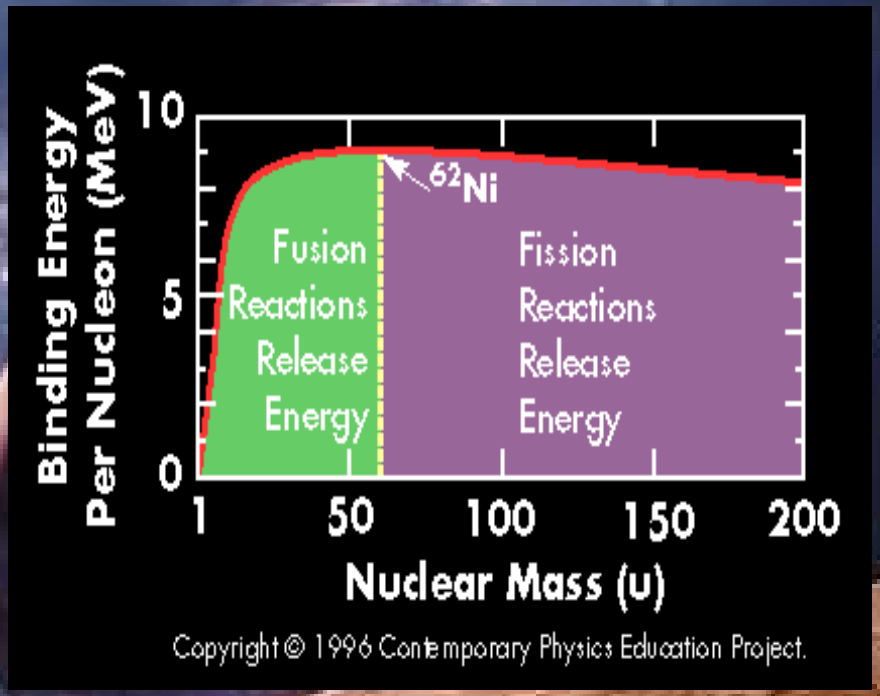
How does fusion produce energy?

- Objects in nature always react so as to have the smallest possible “potential energy,” like a boulder on top of a cliff.
- Each nucleus has a unique “binding energy” which is proportional to its stability
- A nucleus’ binding energy is defined as the energy you must put in to separate a nucleus into its individual protons and neutrons.

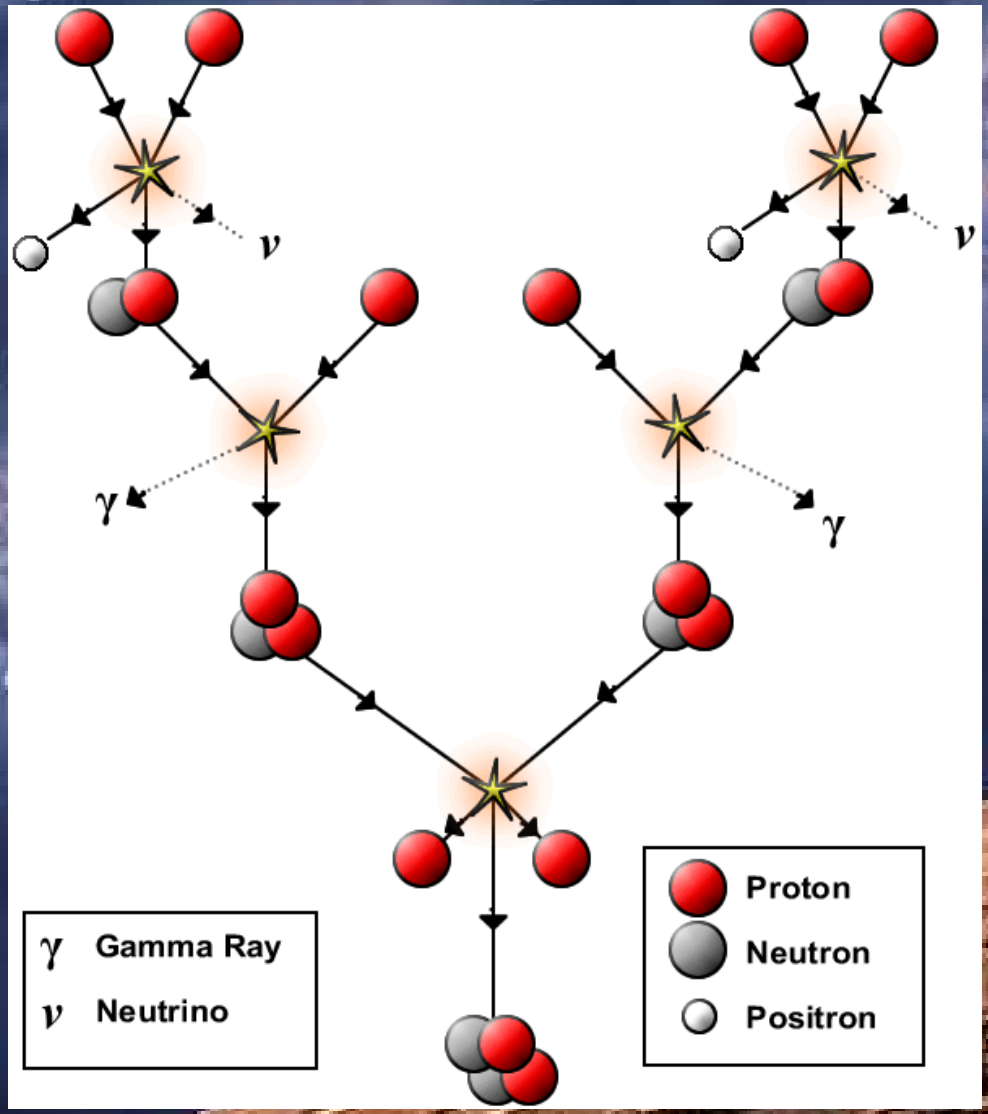


Yeah, but you didn't answer the question.

- Fusion of hydrogen into helium is the primary method of power production in stars.
- Helium is a more stable state of 2 protons and 2 neutrons then two deuterium atoms
- More stable products = more likely reaction

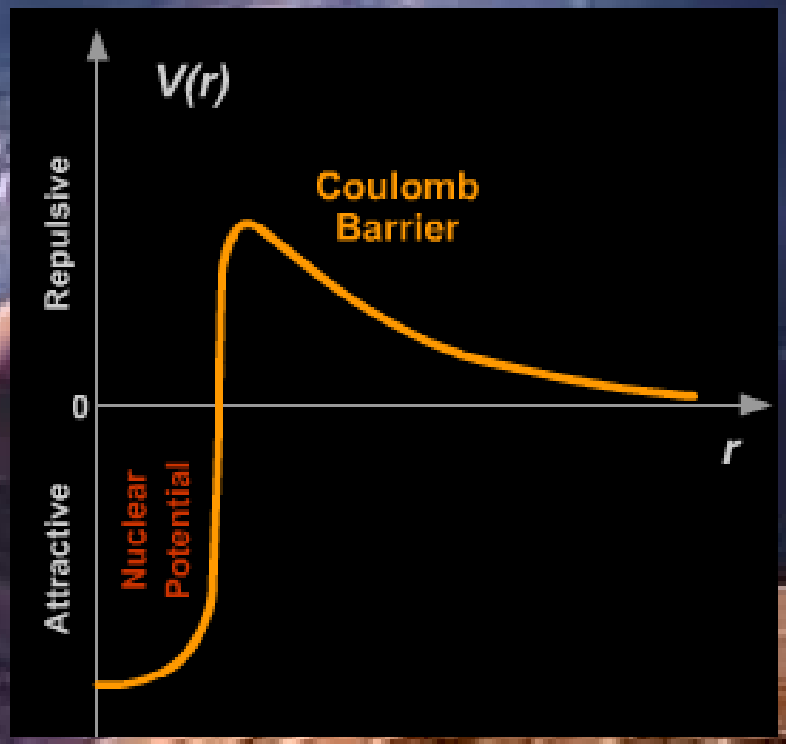


The Proton-Proton Cycle



How can two positive charges attract?

- In the Sun's core, temperatures exceed 13 million degrees Kelvin and the hydrogen density is 150,000 kg/m^3. Under such conditions, nuclei travel so fast that repulsion can be overcome by the nuclear attractive force, causing hydrogen to fuse into helium.



So, like, how do we get light?

- Mass of Dx2 = 4.028u
- Mass of He = 4.0026u
- Difference = .0254u
- This energy difference creates a “photon,” which make up the particles of light, according to Einstein’s formula $E=mc^2$.
- A photon’s energy is related to its frequency by Planck’s Formula, $E=hf$ ($h=6.63*10^{-34}$).

The Death of a Star

- Once hydrogen gets used up, helium fuses into carbon, oxygen, and heavier elements
- Each new fusion event produces less and less energy, and so stars eventually collapse under their own weight