

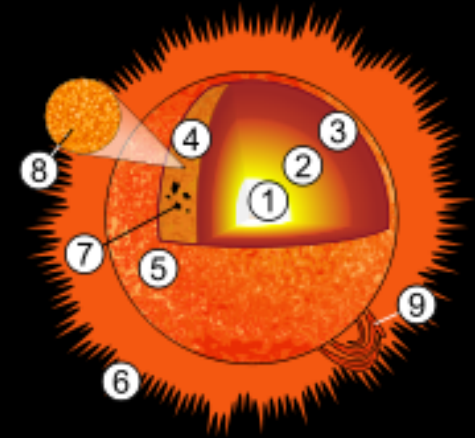
Why do stars shine?

We only figured it out rather recently

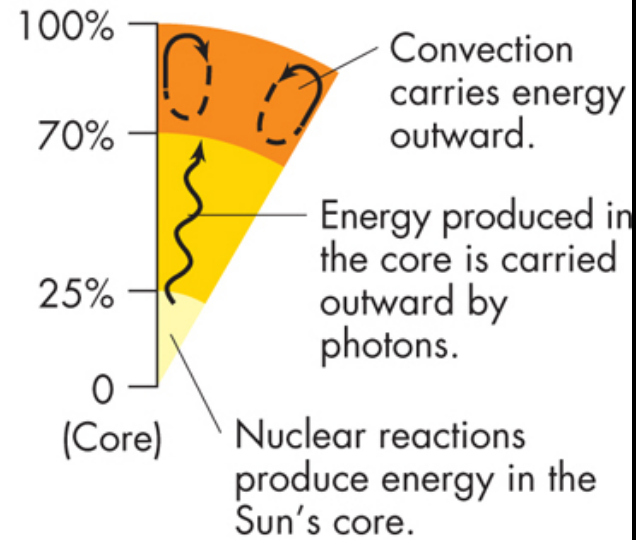
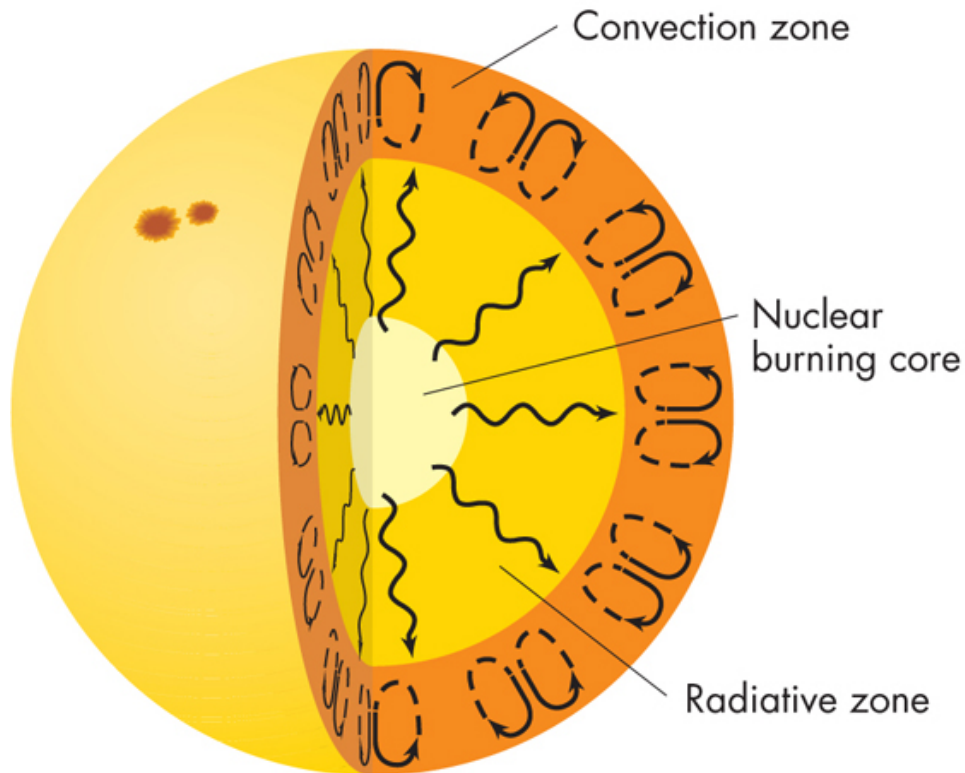
Reading: 17.1-2

Inside the Sun

1. Core
2. Radiative zone
3. Convective zone
4. Photosphere
5. Chromosphere
6. Corona
7. Sunspot
8. Granules
9. Prominence



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How do we know all this?

- Direct observation of the Sun
temperature, spectra, surface waves, sun spots
- Direct observation of other stars
spectra, temperature, size, mass
- Quantum Mechanics (1900's – 30's)
- Nuclear Physics (1920's – 50's)
- Computer Simulations: *magnetohydrodynamics*
- Neutrinos!



Nuclear Physics

1897- electron discovered (J.J. Thompson)

1909 – Atomic nucleus discovered (E. Rutherford)

1913 – “quantized” model of the atom (N. Bohr)

1925 – Quantum Mechanics

1932 – First cyclotron constructed (E.O. Lawrence)

1932 – Neutron discovered (J. Chadwick)

1938 – Nuclear fission discovered (Hahn, Meitner, Strassman)

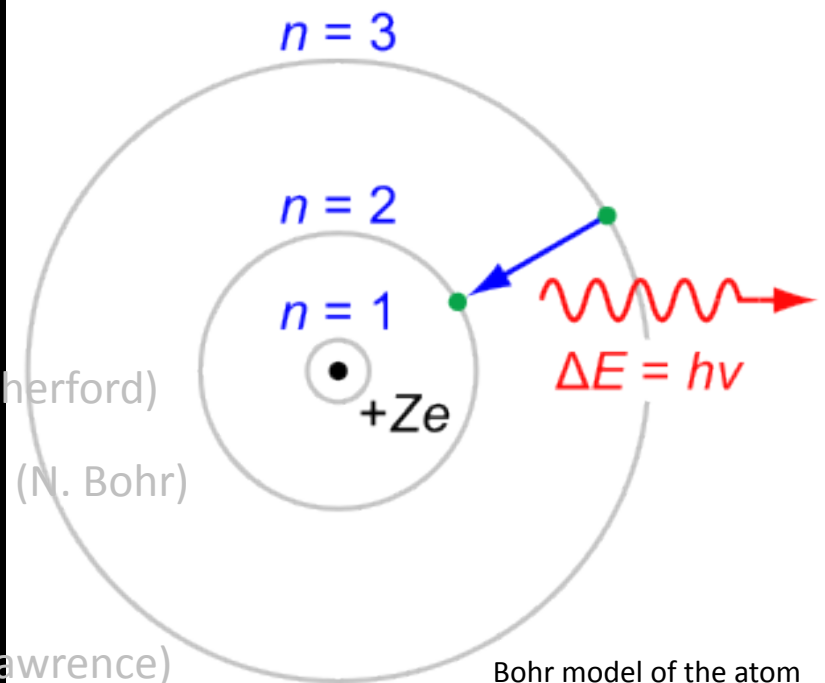
1939 – “Energy Production in Stars” by H. Bethe

1942 – First self-sustaining nuclear chain reaction (E. Fermi)

1945 – First atomic bomb (fission) (Openheimer, Manhattan Project)

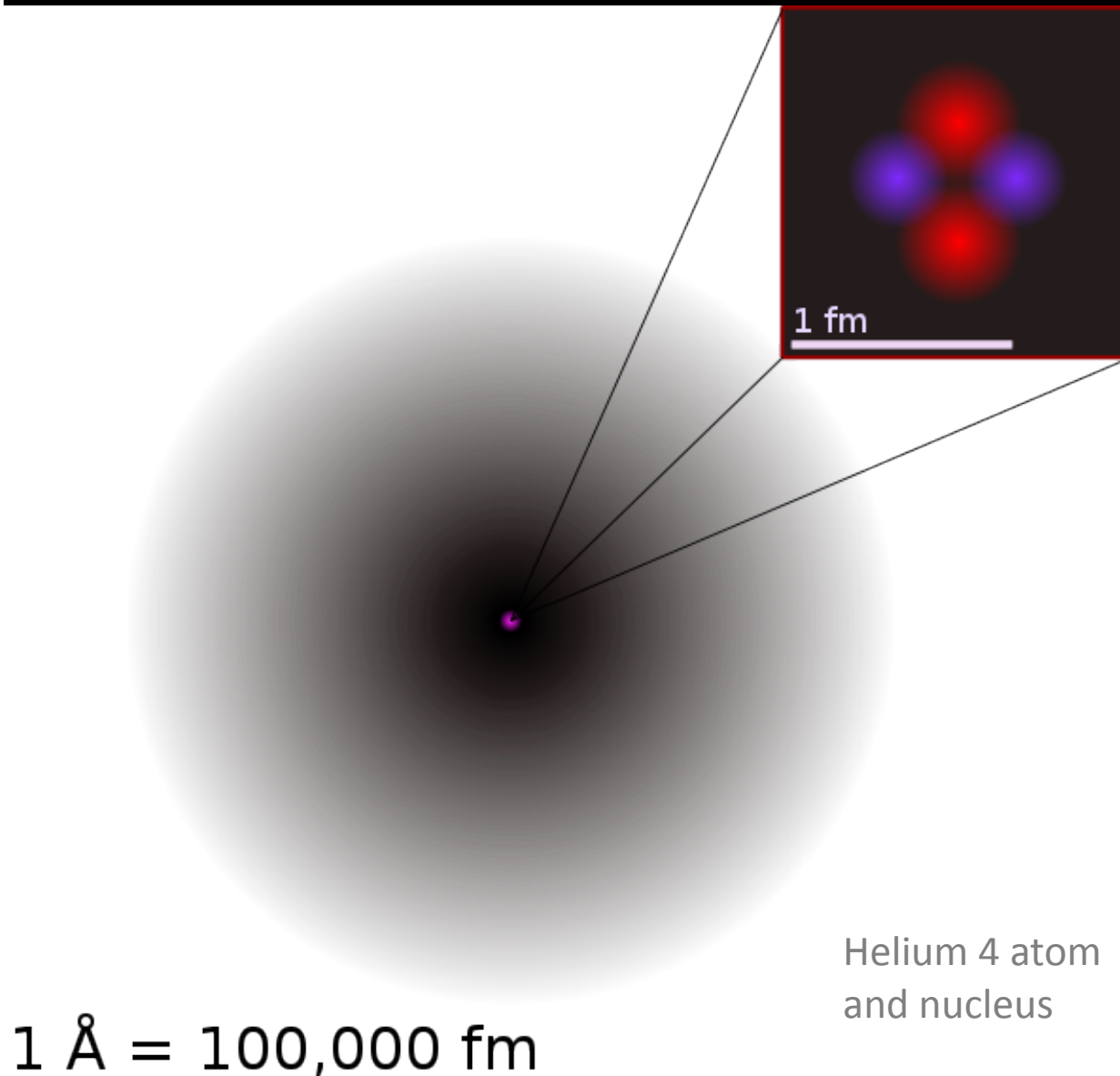
1952 – First hydrogen bomb (fussion) (Teller, Ulam, etc.)

1954 – Nucleosynthesis of heavy elements in stars (F. Hoyle)



Animation...

Atoms and Nuclei



$$1 \text{ fm} = 10^{-15} \text{ m}$$

$$1 \text{ \AA} = 10^{-10} \text{ m}$$

Compare:

$$1 \text{ ly} = 9 \times 10^{15} \text{ m}$$

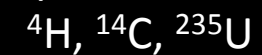
$$1 \text{ pc} = 3 \times 10^{16} \text{ m}$$



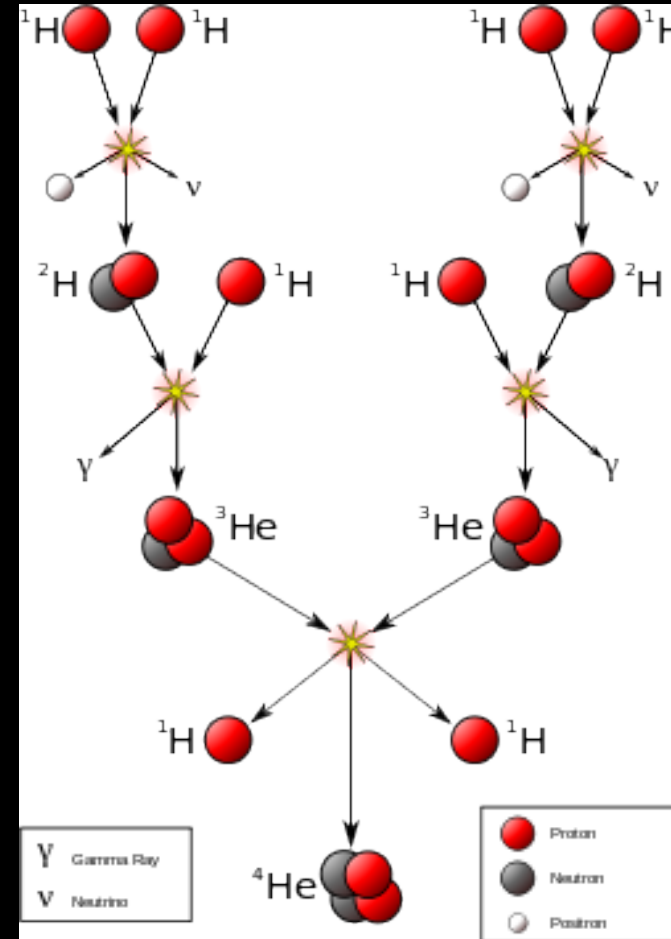
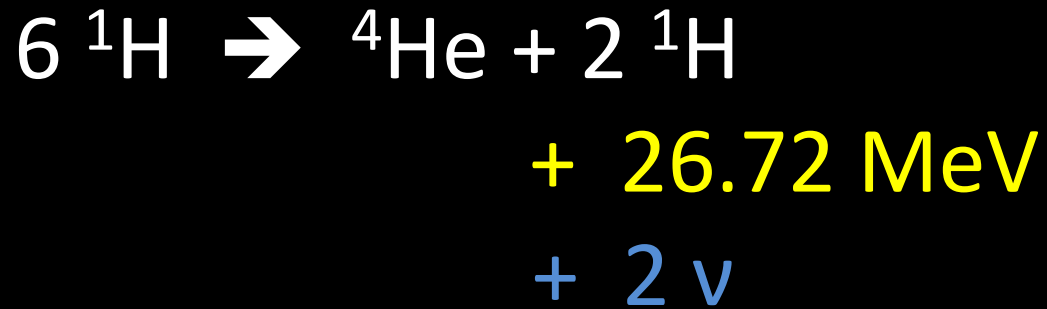
A = Atomic Number

M = Atomic Weight

Examples:

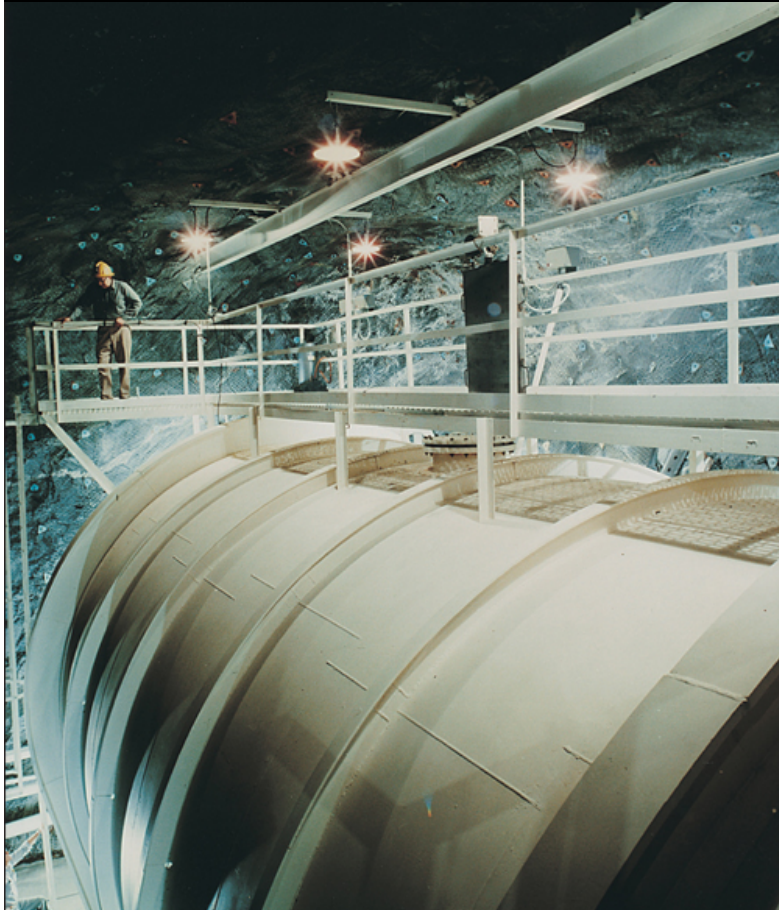


Proton-Proton chain



Animation...

Neutrinos!



Ray Davis' neutrino detector,
Homestake Mine, SD

Kamiokande neutrino detector,
Kamioka, Japan

Cosmic Gall

NEUTRINOS, they are very small.
They have no charge and have no mass
And do not interact at all.
The earth is just a silly ball
To them, through which they simply pass,
Like dustmaids down a drafty hall
Or photons through a sheet of glass.
They snub the most exquisite gas,
Ignore the most substantial wall,
Cold shoulder steel and sounding brass,
Insult the stallion in his stall,
And scorning barriers of class,
Infiltrate you and me! Like tall
and painless guillotines, they fall
Down through our heads into the grass.
At night, they enter at Nepal
and pierce the lover and his lass
From underneath the bed-you call
It wonderful; I call it crass.

*-Telephone Poles and Other Poems,
by John Updike (1960)*

