Summary:

- Nuclear Fusion
- Types of H fusion
- PP chain
- Coulomb barrier
- Binding Energy
- Fusion Shells

Nuclear Fusion

Recap

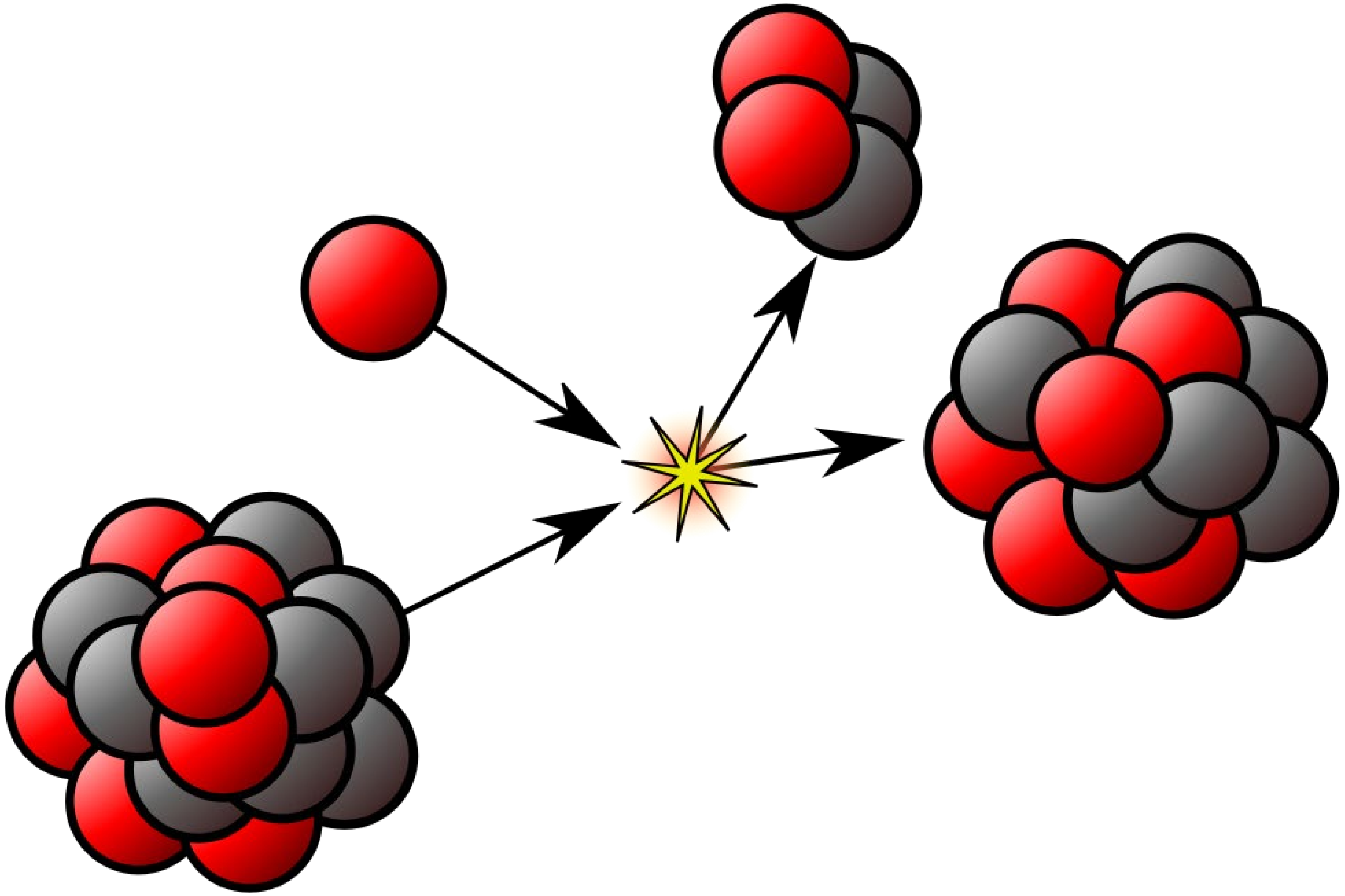
1. Which parts of the EM spectrum are ionising?

2. A star hotter than the Sun would look what colour?

3. How do we identify elements in stars?

Nuclear Fusion

Two or more atomic nuclei combine to form one or more different nuclei and some subatomic particles (protons/neutrons).



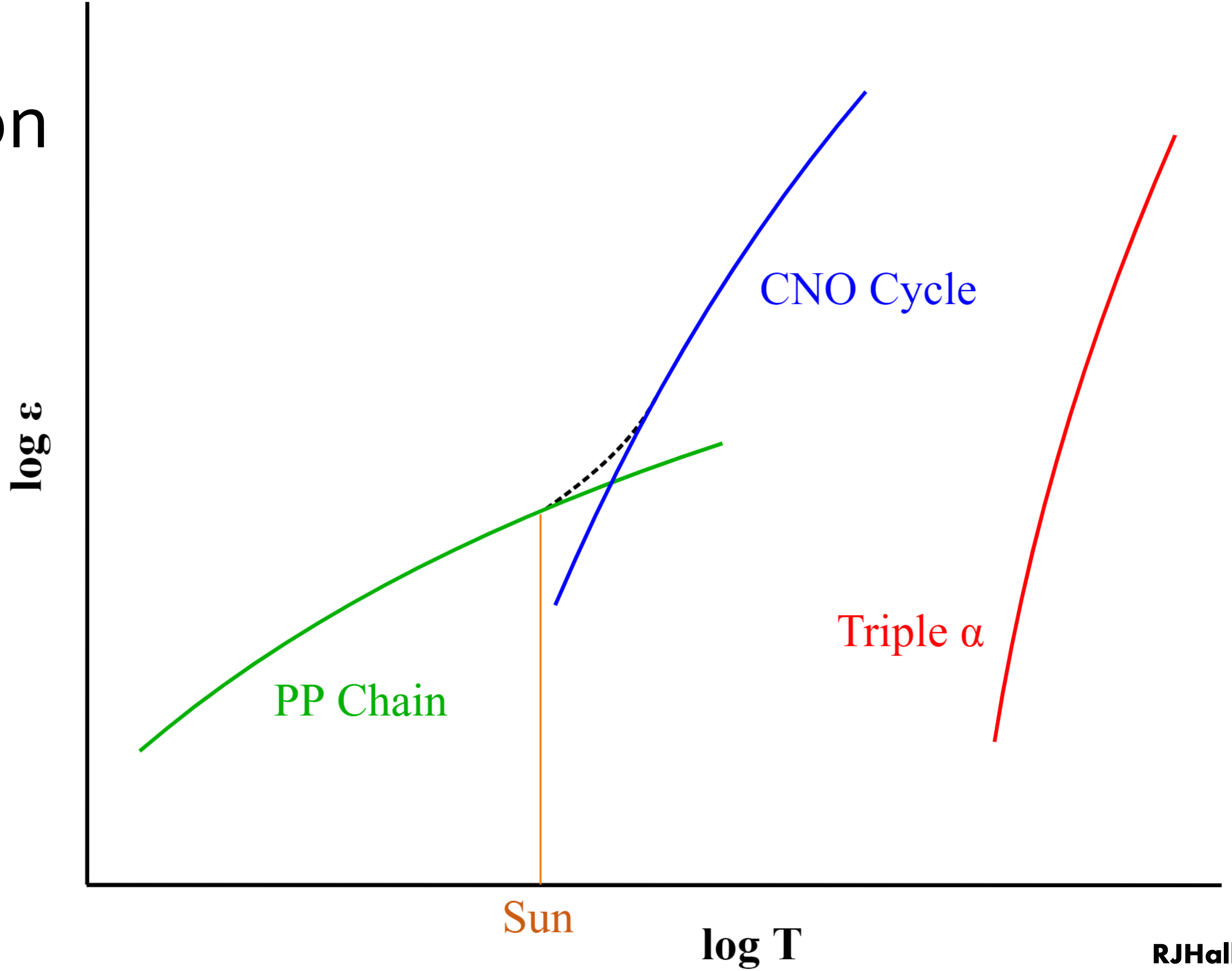
Kjerish

Nuclear Fusion

Three main processes for Hydrogen fusion.

PP Chain fusion at 4×10^6 K.

Core of Sun $\sim 15.7 \times 10^6$ K.



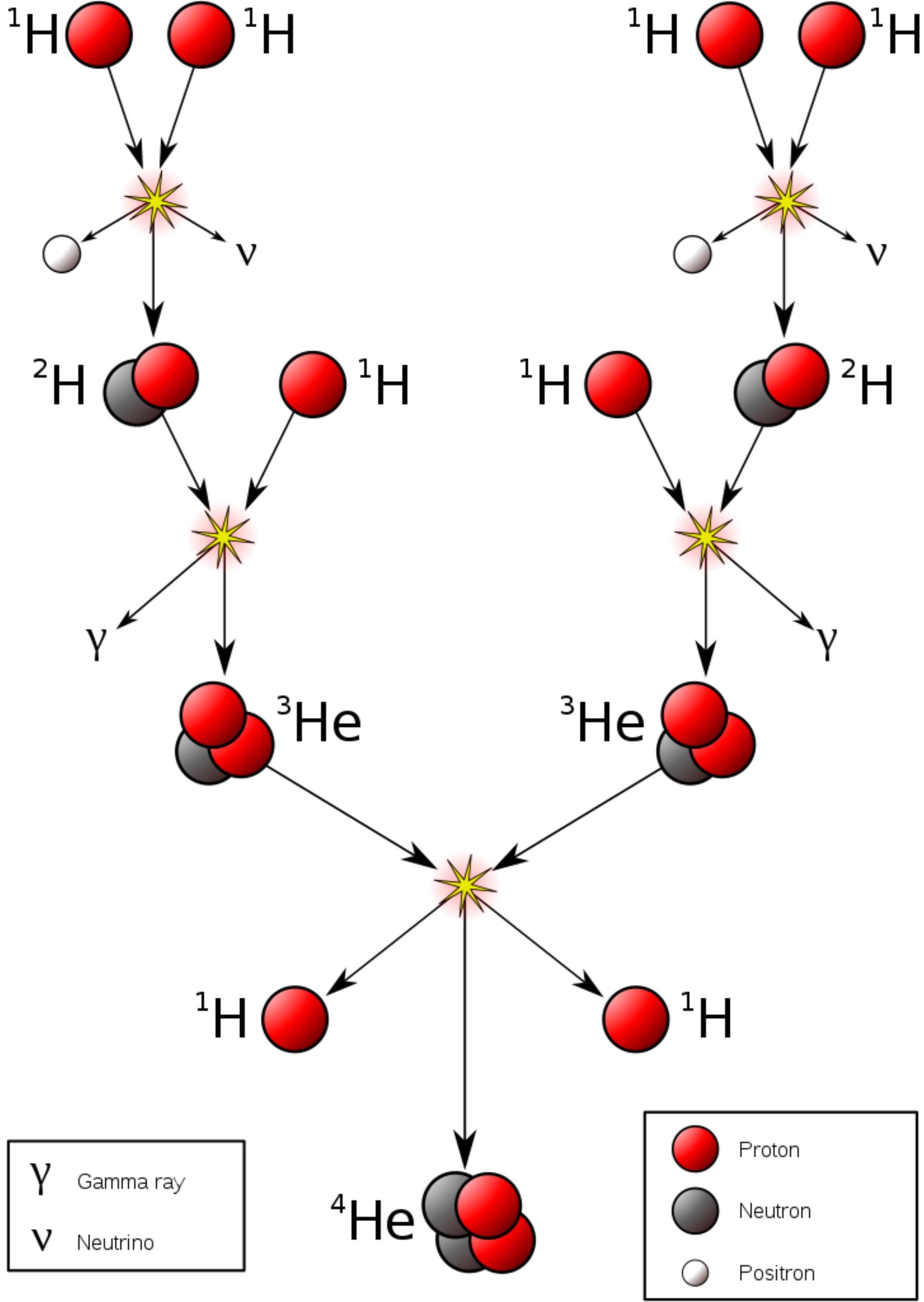
RJHall

PP Chain

The first step takes a VERY long time ~9 BILLION years.

This is because the two Hydrogen nuclei are positively charged and repel.

Total energy released is:
26.73 MeV
(4.3×10^{-12} J)

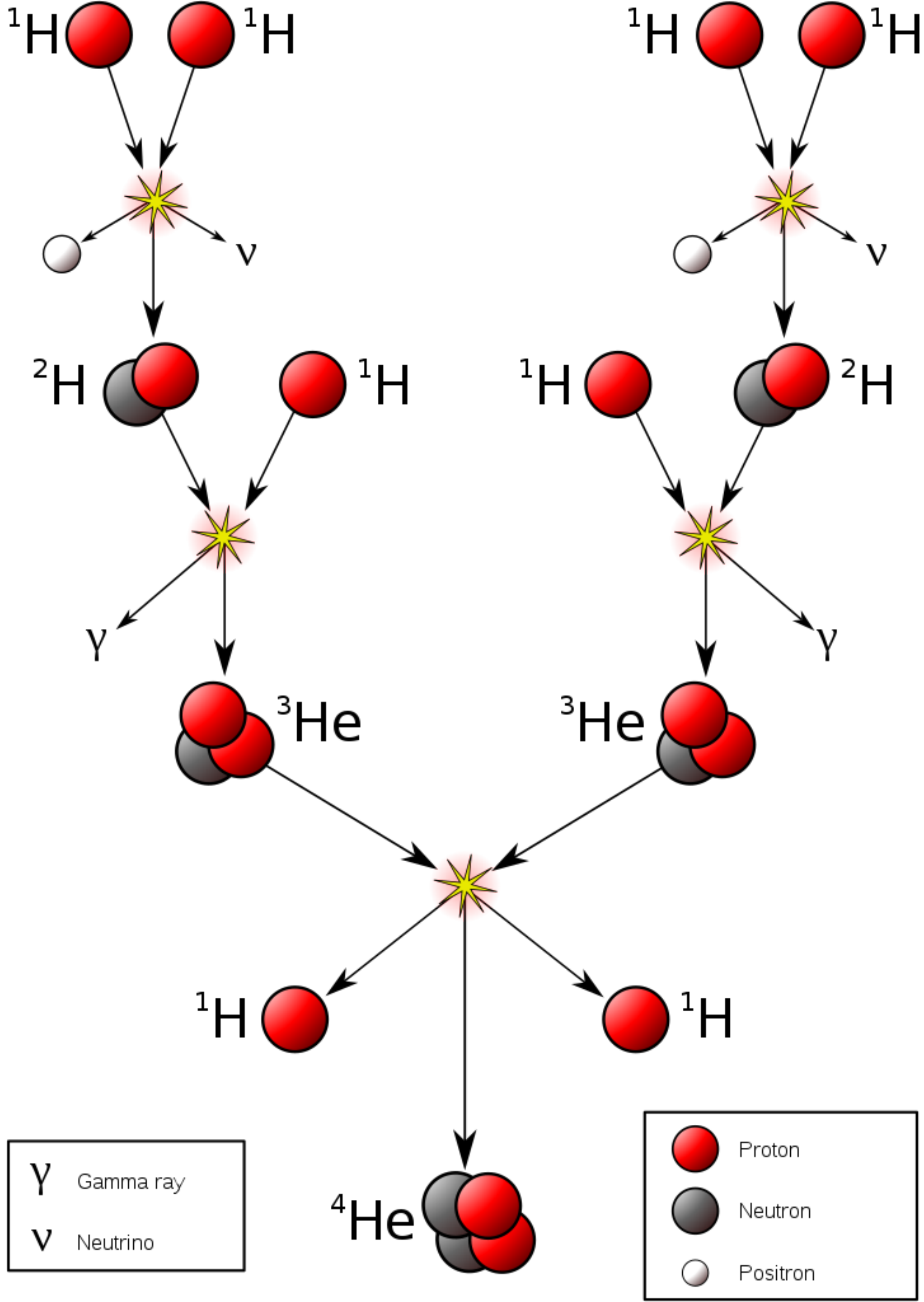


Sarang

PP Chain

$$4\ {}^{1}H^{+} \rightarrow {}^{4}He^{2+} + 2e^{+} + 2\nu_e$$

26.73 MeV



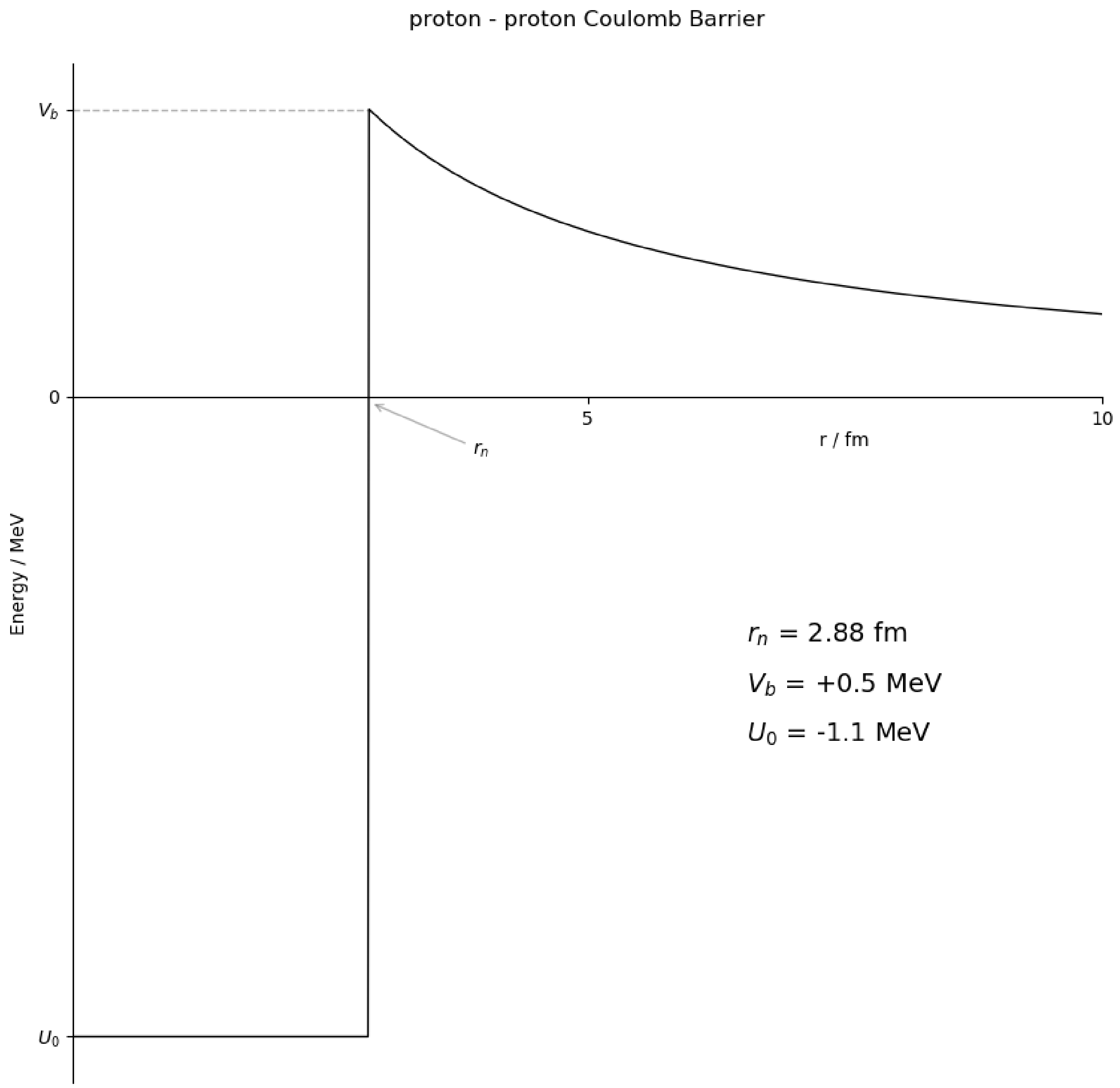
Sarang

Coulomb Barrier

The two protons (Hydrogen nuclei) repel due to the electrostatic force.

They have to have enough energy to overcome the potential barrier (the peak on the diagram).

In practice they cheat using quantum tunnelling.

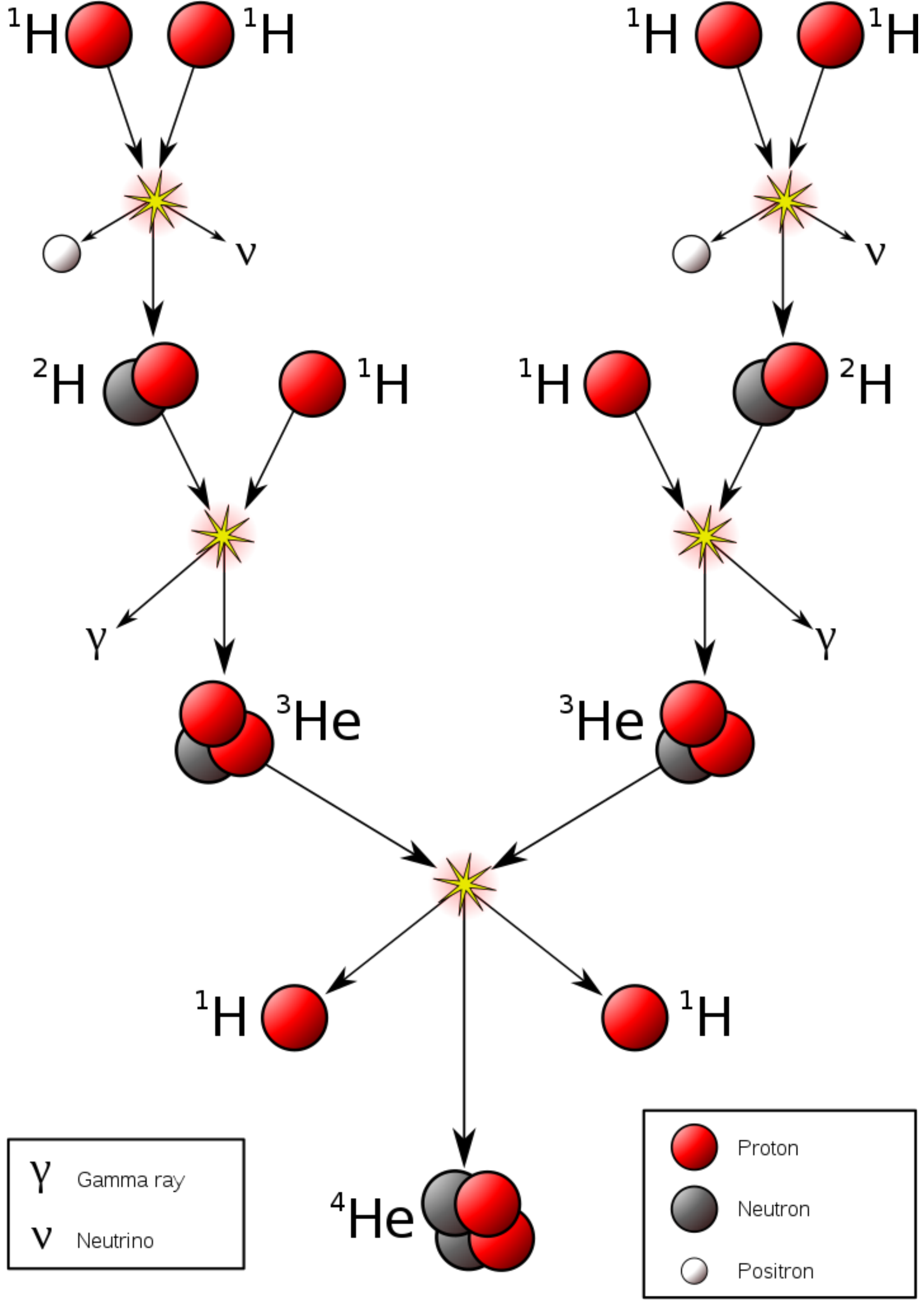


Binding Energy

The mass of the Helium is less than the mass of the four protons.

This mass difference is released as energy.

$$E = mc^2$$



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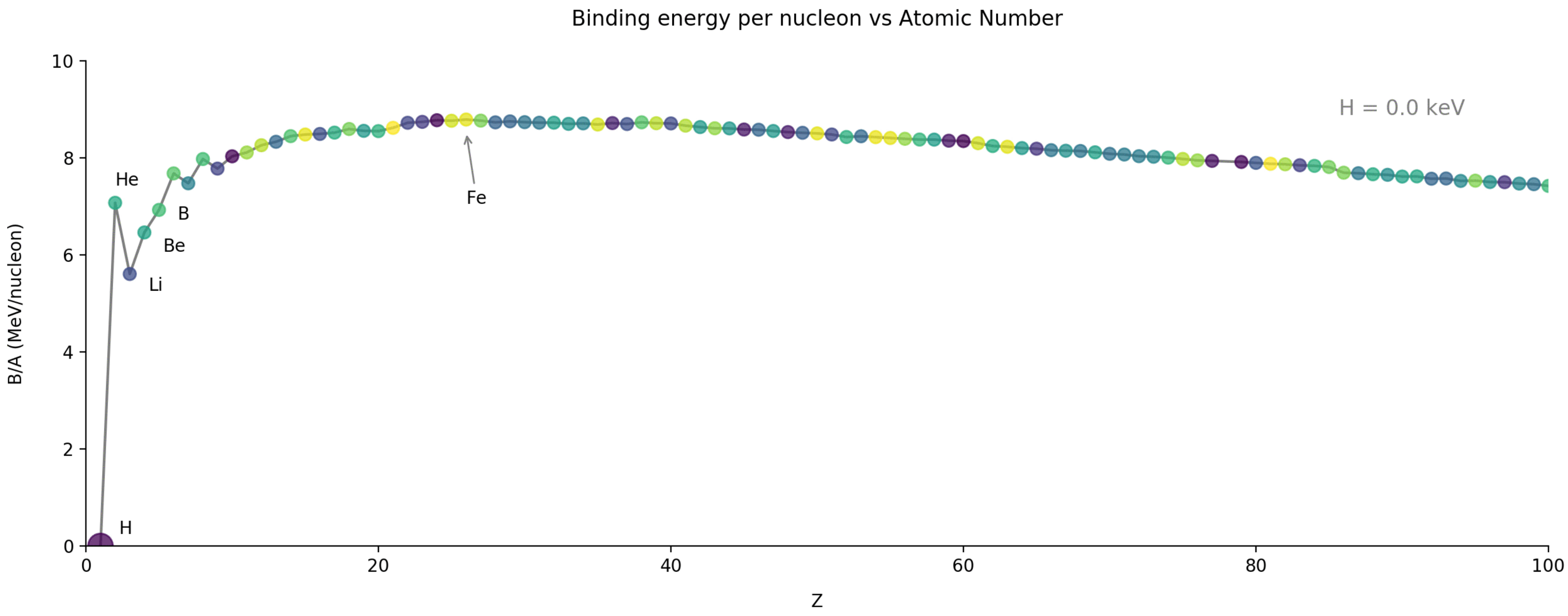
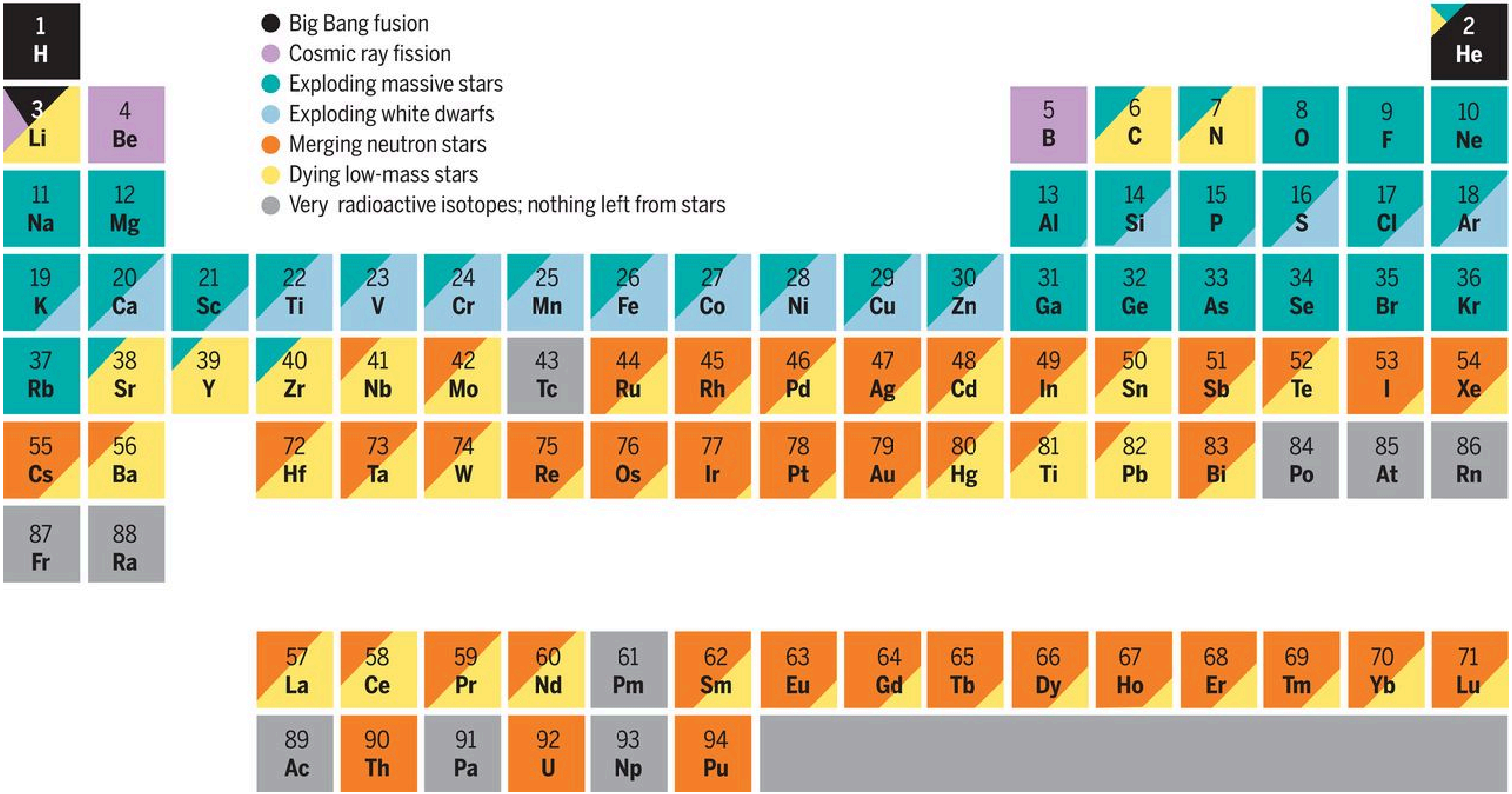
Binding Energy



The evolving composition of the Universe



J.A. Johnson

Recap

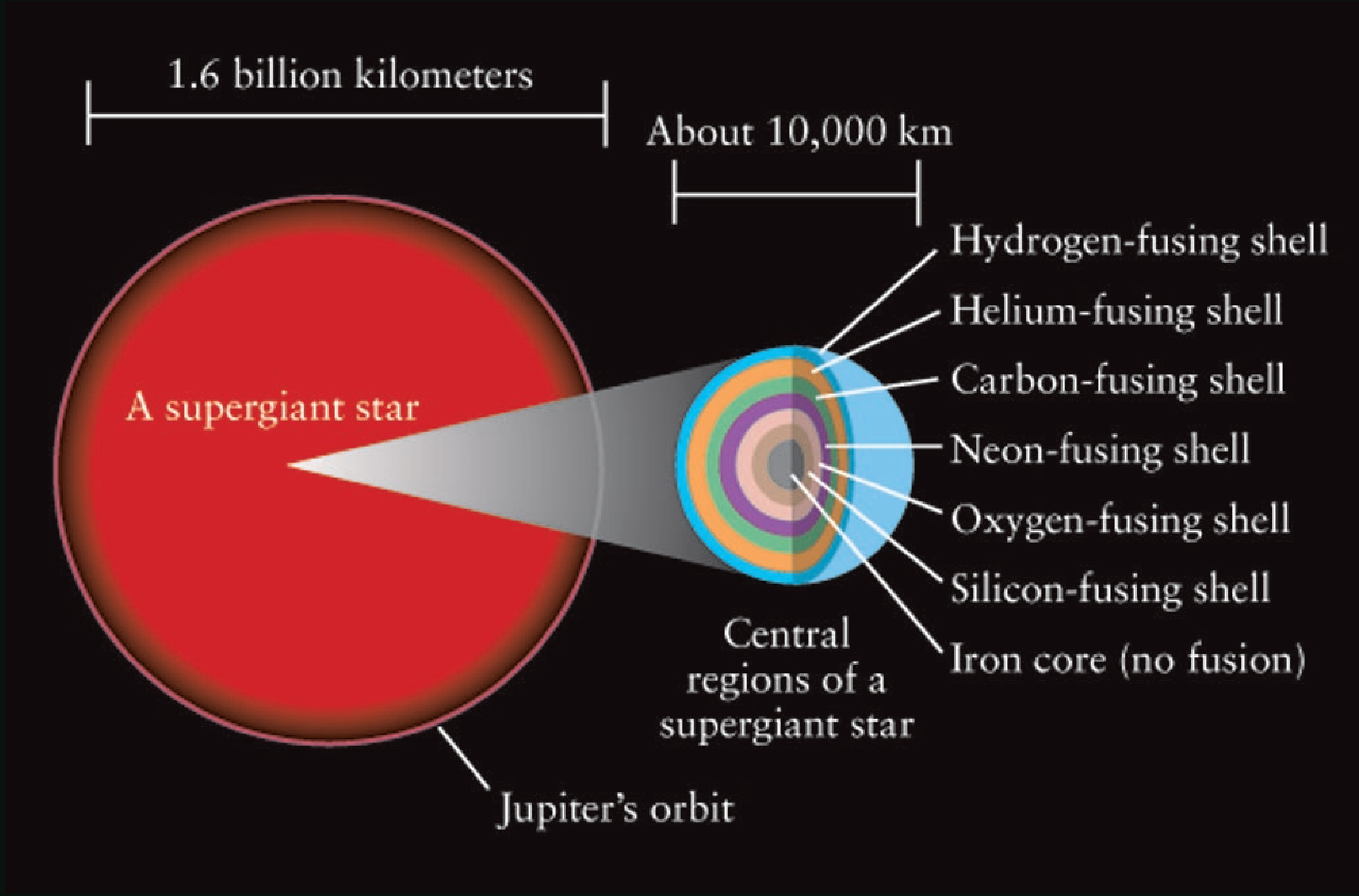
1. Which has more mass: 4 protons or 1 Helium nucleus
2. What force prevents two protons from colliding?
3. Which Hydrogen fusion process dominates at high temperatures?
4. Why can't a star fuse past Iron?

Fusion Shells

Really big stars can fuse up to Iron.

After most of the Hydrogen is used you have a lot of Helium which sinks to the centre.

This heats up the star so that it can fuse Helium and causes a Helium flash.



D Pogosyan

25 Solar Mass Star

Fusion type	Duration	T (10^9K)	ρ (kg.m^{-3})
H Burning	7×10^6 yrs	0.06	5×10^4
He Burning	5×10^5 yrs	0.23	7×10^5
C Burning	600 yrs	0.93	2×10^8
Ne Burning	1 yr	1.7	4×10^9
O Burning	6 months	2.3	1×10^{10}
Si Burning	1 day	4.1	3×10^{10}

Mass vs Fusion Process

Mass	**Fusion type**
0.1 - 0.5 $M_\odot$	H burning but no He burning
0.5 - 8 $M_\odot$	H and He burning
8 - 10 $M_\odot$	H, He and C burning
> 10 $M_\odot$	All stages of thermonuclear fusion
core < 1.4 $M_\odot$	White dwarf (He, C/O, O/Mg/Ne)
core > 1.4 $M_\odot$	Core will collapse, supernova

Recap

1. What shell comes after Helium?
2. Does the Hydrogen at the very edge of the star fuse?
3. Which lasts longer Helium or Neon burning?
4. Define hydrostatic equilibrium.

Up next:

Observing the Night Sky