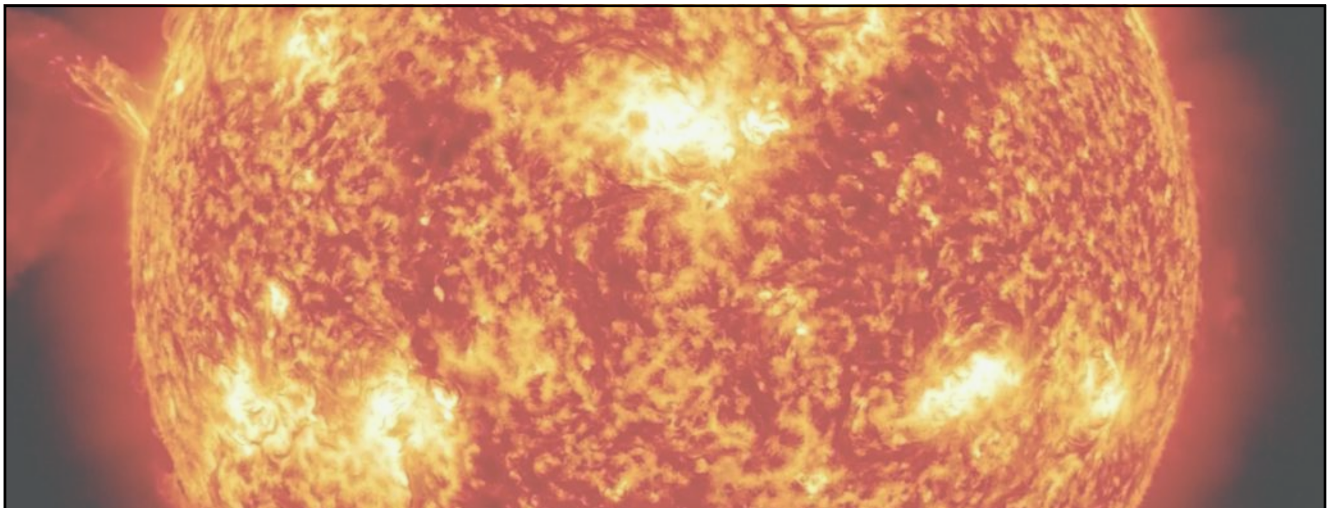


The Fate of Our Sun

Jack Scobie, Taylor Reimer, Chase Bayko, Sean Finlay

Outline

Timeline

Universe is Formed

13.77 Billion Years Ago

Milky Way is Formed

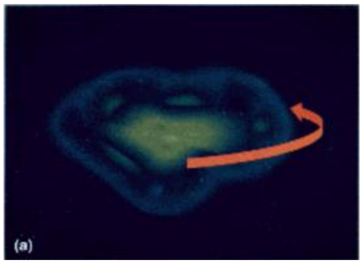
13.6 Billion Years Ago
(+/- 800 Million Years)

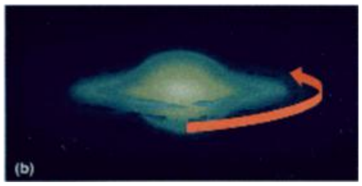
Our Sun is Formed

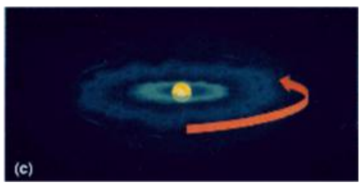
4.6 Billion Years Ago

Formation of Sun

- Formed by Solar Nebula
- Solar Nebula: Giant, rotating cloud of gas and dust
- Solar Nebula collapses to form sun

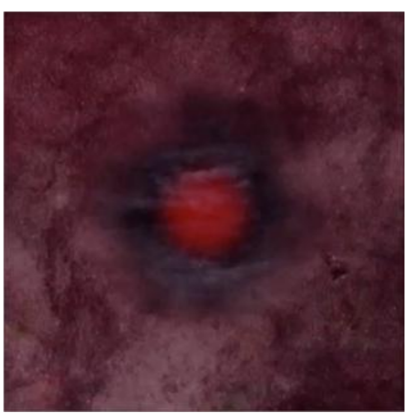






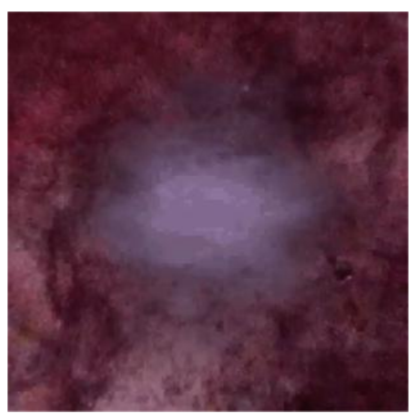
- Asymmetrical density distribution causes contraction
- Nebula has a net rotation, and the speed of rotation increased due to the Conservation of angular momentum
- Gravitational potential energy converted to kinetic energy which is given off as heat
- Hot region near centre becomes protosun

Formation of Nebula



- Large spinning nebula is formed
- Low density – several LY across

Solar Nebula



- Collapse most efficient along spin axis
- Higher density – 0.003LY across

Collapse Continues

Protosun

Collapse continues and temperature rises

Fusion Begins

At 10,000,000K fusion of atoms occurs and the sun is formed

Collapse Stops

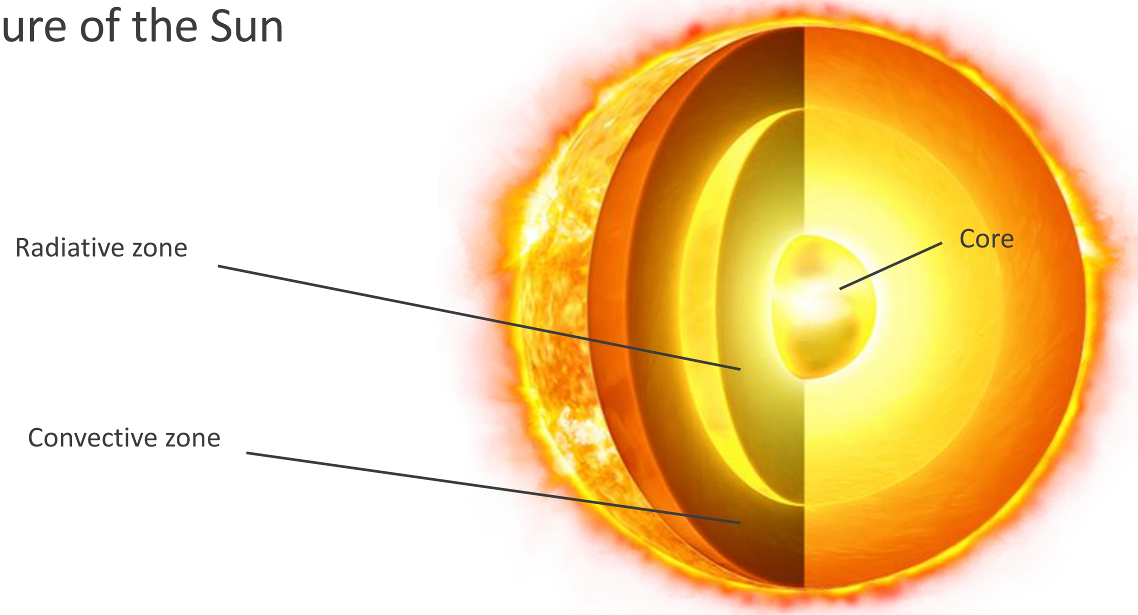
Hydrostatic equilibrium prevents further collapse – gas pressure inside the star opposes the inward force of gravity

Demo: Hydrostatic Equilibrium

- Balloon is used to represent the sun
- Latex elasticity of balloon is analogous to inward gravitational force acting on Sun
- Air inside balloon is analogous to outward gas pressure of the Sun

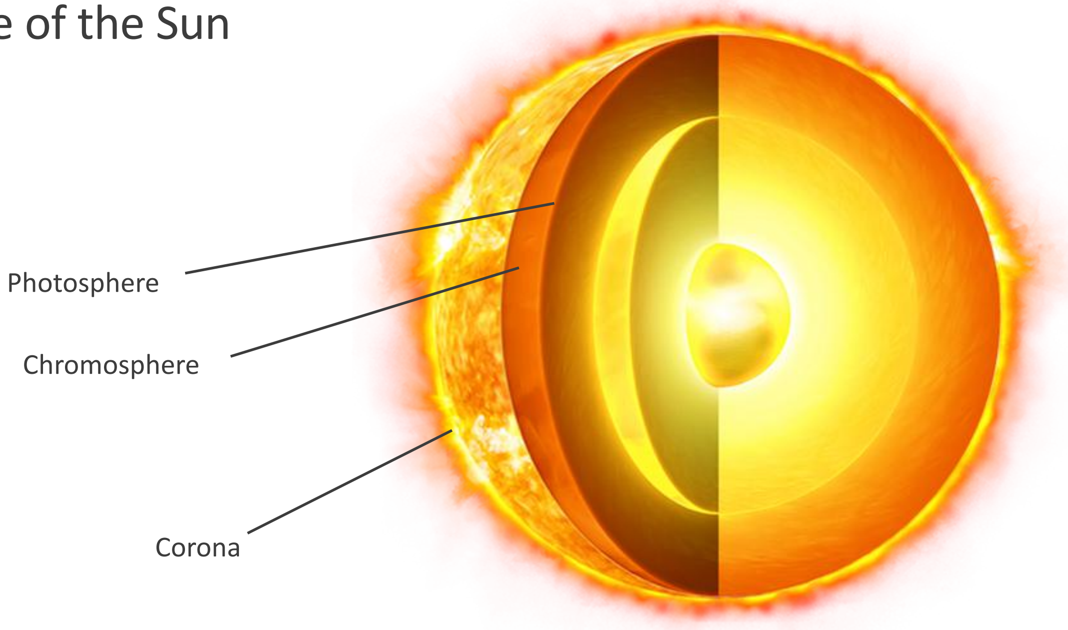
Structure of the Sun

Layers:

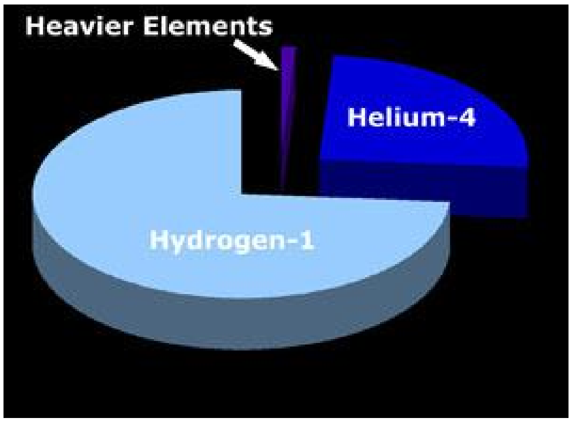


Structure of the Sun

Layers



Structure of the Sun



Composition

Hydrogen (~74 %)

Helium (~25 %)

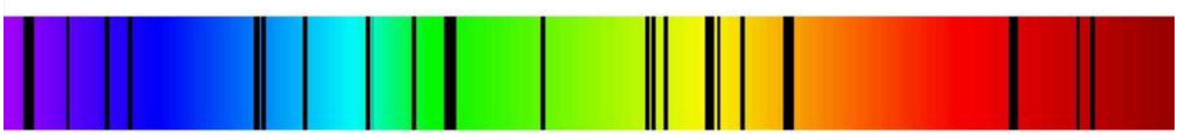
Other elements (<2 %)

Structure of the Sun

Composition

Measured using:

- Spectroscopy of the sun's photosphere



Structure of the Sun

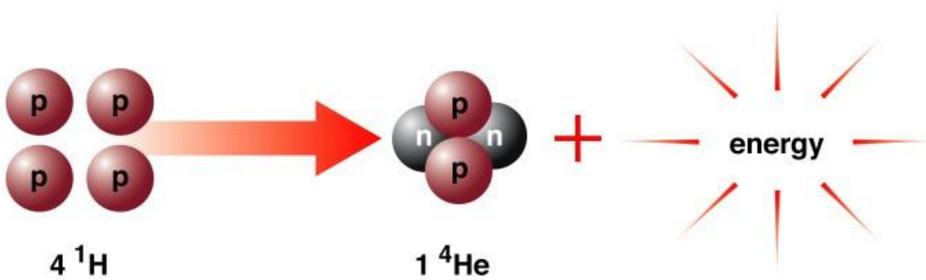
Composition

Measured using:

- Abundances in meteorites that have never been heated to melting temperatures

Structure of the Sun

Nuclear Fusion



Structure of the Sun

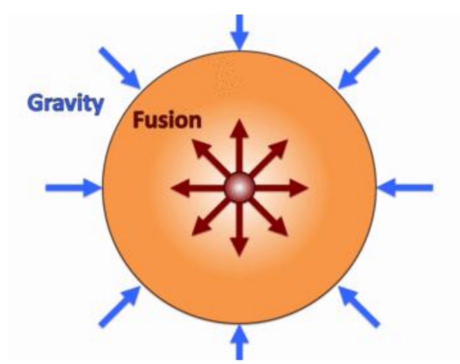
Nuclear Fusion

- Temperature requirements:
  - Kinetic energy of particles must be high
  - Quantum tunnelling decreases necessary temperature

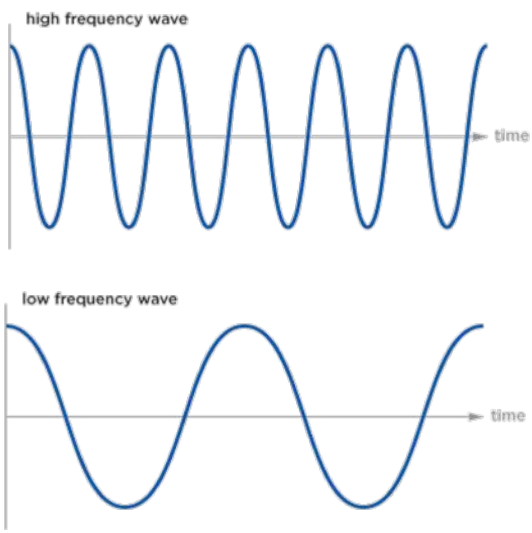
Structure of the Sun

Nuclear fusion

- Confinement requirements
- Plasma tends to expand immediately and some force is necessary to act against it
  - Gravitation serves this purpose in stars



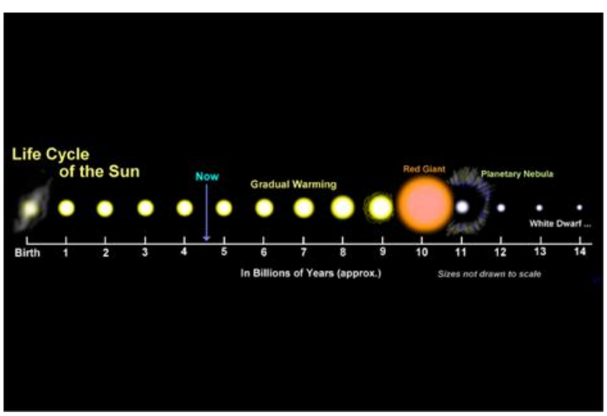
Structure of the Sun



Age

- Rubidium dating
- Brightness
- Vibrational frequencies

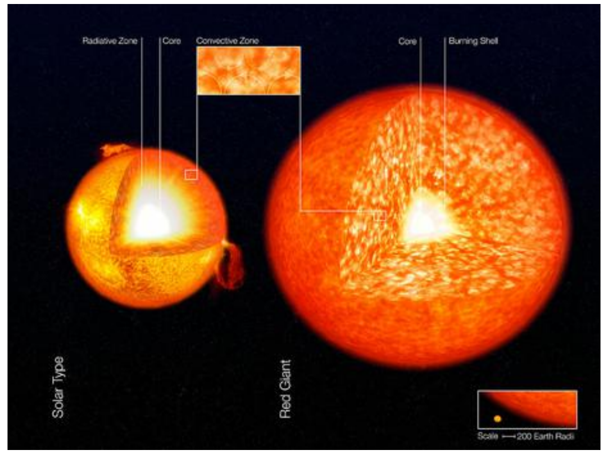
Main Sequence Stage



- Current stage of the Sun
- Lasts for ~10 Gyr
- During stage reaches peak temp of 5820K and luminosity is $1.26L_{\odot}$

Red Giant Branch (RGB) Phase

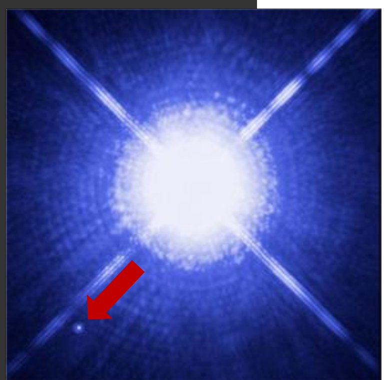
- Lasts for ~2 Gyr
- During this phase the Sun would expand to engulf Mercury, and Venus and Earth
- Temperatures cool and luminosity increases



Asymptotic-Giant Branch (AGB) Phase

- Lasts ~600 million years
- Nuclear fusion occurs using helium instead of hydrogen
- At the end of the phase creates a planetary nebula and a white dwarf

What is a White Dwarf?

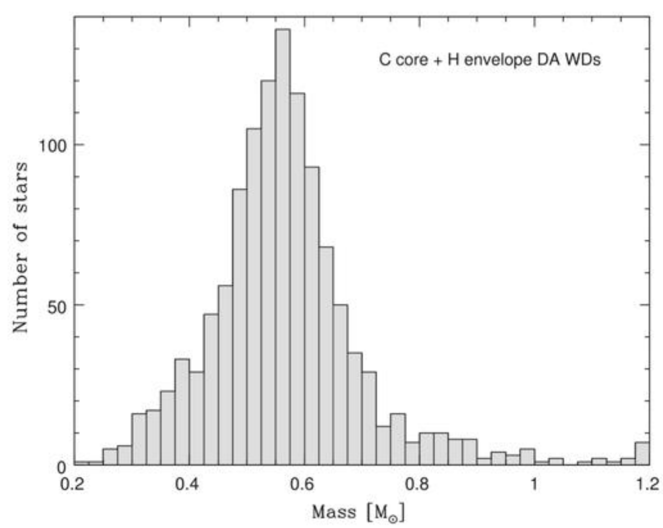


- End stage of life cycle for intermediate/small mass stars
- Extremely dense (10^9 kg m^{-3}) → Extreme Gravity
- Cool from ≊ 100,000 K to near 4000 K (10-12 billion years)
- Comprised of:

i. Fusion byproducts at the core
ii. Helium and hydrogen at surface
iii. Thin atmosphere

Why Study White Dwarfs?

- Used to test our understanding of the behaviour of matter under extreme conditions
- Mass distribution of white dwarf populations in Milky Way conveys information about evolution of our galaxy



Ultimate Fate of White Dwarfs

1. **The white dwarf cools to a black dwarf (most likely fate for our sun)**
2. White dwarf in a binary system can take up mass and result in in thermonuclear supernovae or neutron star
3. Those in a binary system may also collide to create supernovae