Session 7: Stars and Their Lives (Part II)

This presentation supports the "Background" material in Session 7 of the Afterschool Universe program. This is the second (and optional) of two sessions concerning the properties and workings of stars.

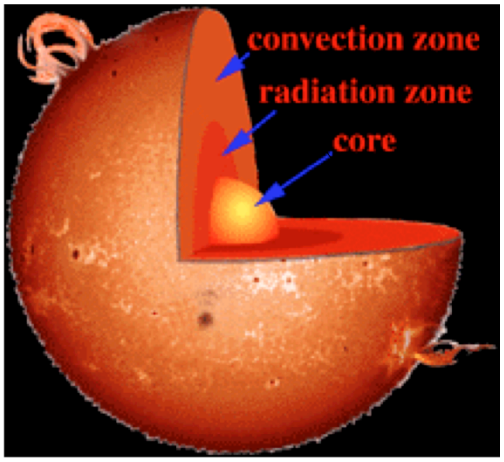
The Main Concepts…

1. Stars generate energy by "cooking" elements in their cores.

2. Many of the elements that we find in the world are made inside of stars. They are released when the stars explode in supernova explosions.

Let us summarize the main concepts in this Session. We will discuss these in the rest of this presentation.

How Do Stars Make Energy?



Sun generates energy in its core by "cooking" hydrogen to form helium


Afterschool Universe


Let us recap how stars make their energy.

A star such as the Sun generates its energy in its core. The energy is generated by a process known as nuclear fusion. Think of nuclear fusion as a form of cooking… the core of the Sun is very hot (15 million degrees celsius), and the hydrogen is "cooked" and forms helium.

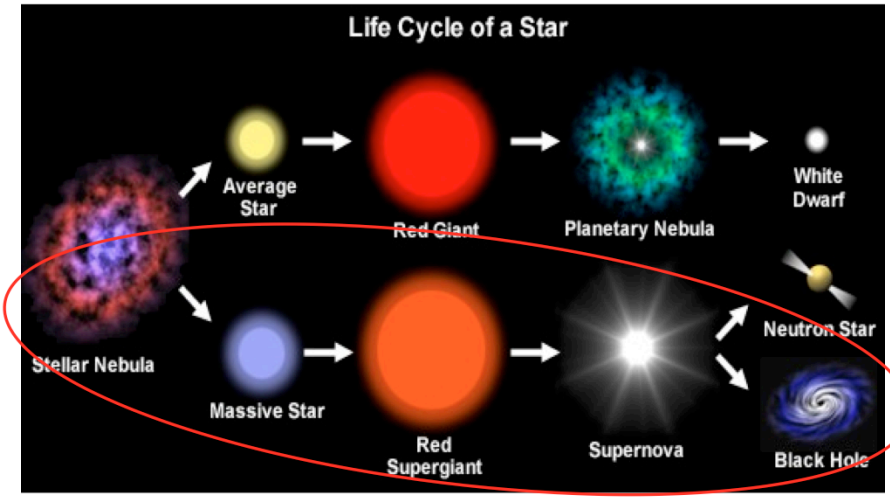
Nuclear Fusion

- This "cooking" of elements is called **nuclear fusion**
- During nuclear fusion, two or more atoms of one element combine to form one atom of a different element
- During most of their lives, stars make energy by turning hydrogen into helium
  - 4 hydrogen atoms → 1 helium

In nuclear fusion, two or more atoms (or more precisely the nuclei of those atoms) merge together to form a new atom (nucleus).

The precise processes are a little complicated but 4 hydrogen atoms need to fuse together to form helium. Each second, the Sun converts 600 million tons of hydrogen into helium.

Life Cycles of Massive Stars



We have already discussed the evolution of a low-mass star in the previous session. We will now discuss how massive stars cook elements in their cores.

Life Cycles of Massive Stars

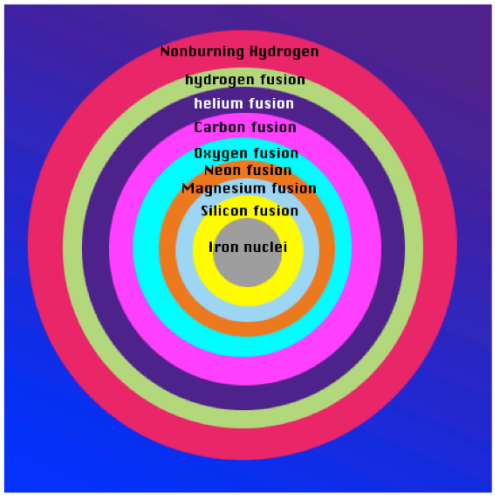
- **A massive star will…**
  - Run out of hydrogen after a few million years
  - Will carry on cooking elements…
    - Helium→Carbon→Oxygen→Neon→Magnesium→Silicon→Iron
  - Nuclear fusion process stops at iron. The star cannot release anymore energy once iron has been made.
  - Without energy generation, gravity causes core of star to rapidly collapse (in a few seconds).
  - Energy released from collapse causes rest of star to explode in a **SUPERNOVA!**
  - After the supernova, we are left with a superdense object, either a **neutron star** or a **black hole**.

What about a massive star?

Massive stars live life in the fast track… they shine very brightly but run through their hydrogen fuel very quickly, in just a few million years. After they run through their hydrogen, they keep on cooking elements.

The sequence of elements stops at iron - energy cannot be generated by fusing anything with iron. Without energy generation, the star collapses giving a supernova explosion as discussed in the last session.

Interior of a Massive Star



Just before a supernova, the inside of the star has shells of various elements.

Just before the explosion, the star has an "onion shell" structure… iron in the core, surrounded by shells of silicon, magnesium, neon, oxygen, carbon, helium and (on the outside) hydrogen.

Elements in the Universe

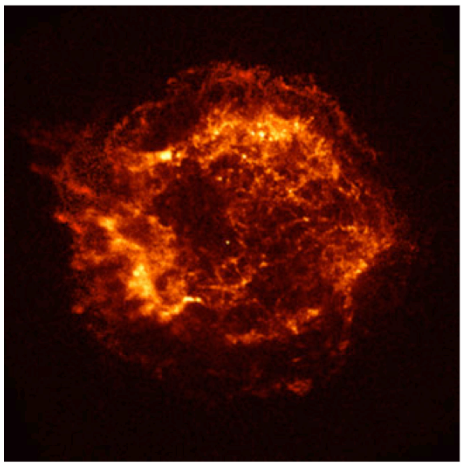
- Hydrogen and some helium was made at the beginning of the Universe (Big Bang).
- All other elements were made inside of stars, and then spewed out into space by the supernova explosions!
- What about elements with atoms heavier than iron? Such as Uranium, Gold, and so on?
  - The heavy atoms are made during the supernova explosion itself!
  - There is so much energy during the explosion that iron atoms can be forced together to form larger atoms.

Supernova are the source of most elements in the Universe…

Hydrogen and (some of the) helium have been around since the beginning of the Universe. But all of the other elements that we see around us were made inside of stars and spewed into space in supernova explosions.

What about elements heavier than iron such as Uranium, Silver or Gold? They are made during the supernova explosion itself when the temperature gets even hotter than in the core of the star!

Supernova Remnants



X-ray picture of the "Cas-A" supernova remnant. The elements in this gas will eventually be dispersed into space, maybe to form new stars, planets and people!

We actually see elements in the debris of old supernovae (known as supernova remnants). This is an X-ray picture of the supernova remnant Cassiopeia-A taken with the Chandra X-ray Observatory. This expanding cloud of very hot gas is loaded with elements that will eventually be distributed through space.