

Observational Astronomy - Spring 2014

Homework 8 - Stars II

1. What are the three types of stars that represent the end-points of stellar evolution? These are where stars end up after they have burned their nuclear fuel. List them in order from the largest to the smallest.

- In decreasing order of size, they are (1) White dwarfs, (2) Neutron stars, and (3) Black Holes.

2. We said an approximate way to view the size of the event horizon of a black hole is when the escape velocity, given by $V = \sqrt{2GM/R}$ is equal to the speed of light. Given this, how small would we have to compress the Earth to make it a black hole?

- The mass of the Earth is about 6×10^{24} kg, and the speed of light is about 3×10^8 m/sec, so in order to have a black hole, we need:

$$V = \sqrt{\frac{2GM}{R}}$$

- Solving for R, and setting the escape velocity equal to the speed of light gives:

$$R = \frac{2GM}{c^2} = \frac{2 \times 6.7 \times 10^{-11} \frac{\text{m}^3}{\text{kg s}^2} \times 6 \times 10^{24} \text{ kg}}{(3.0 \times 10^8 \frac{\text{m}}{\text{s}})^2} = 9.0 \times 10^{-3} \text{ m} = 9 \text{ mm!}$$

- Imagine the force necessary to crush the Earth down to the size of a marble!

3. Where were elements heavier than helium, such as the elements that make up the Earth, or the carbon in your body, produced?

- They were generated by nuclear fusion in the cores of massive stars.

4. What do we call the explosion that results when a massive star reaches the end of its life? Will all stars produce these explosions? If not, what is required to produce them?

- They are called supernovae (singular is supernova). Only massive stars more than about 8 times the mass of the sun produce them.

5. About how old is the sun? About how much longer do we expect it to live? Describe the stages it will go through at the end of its life. How will these events impact life on Earth?

- The sun is about 4-5 billion years old. We expect it to live for about another 5 billion years. At the end of its life, it will swell up into a red giant, then eject its outer layers, forming a planetary nebula surrounding a white dwarf star.

6. How were the first neutron stars discovered? What type of instrument was used to observe these objects?

- Pulsating radio sources, called pulsars, were discovered using radio telescopes. It was soon realized that these objects were spinning neutron stars.