Observational Astronomy - Spring 2014
Homework 7 - Stars I

1. The Hipparcos satellite has a stated measurement accuracy of 0.002 arc seconds. How far away in parsecs is a star with a parallax of 0.002 arc seconds? How far is this in light-years?

   - Looking at how parallax is derived, we see that the distance is inversely proportional to the parallax. So a star with a parallax of .002 arc seconds is at a distance of

$$\mathrm{D} = \frac{1}{.002} = 500\,\mathrm{parsecs} = 500\,\mathrm{pc} \times 3.26\frac{\mathrm{light-years}}{\mathrm{pc}} = 1630\,\mathrm{light-years}$$

2. We calculated that the intensity of radiation from the Sun at the Earth's orbit is about 1400 $\frac{\mathrm{Watts}}{\mathrm{m}^2}$. What is the intensity of solar radiation at the planet Neptune, at a distance of 30 AU from the Sun? Are solar cells a good way to power a spacecraft traveling to Neptune?

   - The intensity of the radiation falls off according to the inverse-square law, so the intensity at Neptune is:

$$\mathrm{I} = 1400\frac{\mathrm{Watts}}{\mathrm{m}^2} \times (\frac{1\,\mathrm{AU}}{30\,\mathrm{AU}})^2 = 1.55\frac{\mathrm{Watts}}{\mathrm{m}^2}$$

   - Spacecraft take hundreds to thousands of watts of power, so it would take really large solar cells to power a spacecraft at Neptune, too large to be practical. For this reason, deep-space missions are nuclear powered.

3. What process powers the stars? What element does the Sun consume for fuel and what element is produced in this reaction?

   - The stars are powered by nuclear fusion.
   - The sun is primarily powered by fusing hydrogen into helium.

4. A star with 10 times the mass of the Sun has 10 times as much nuclear fuel as the Sun. Yet it lives for a much shorter time, only about 50 million years as compared to 10 billion years for the Sun. Explain why.

   - Although a star ten times more massive than the Sun has 10 times as much nuclear fuel as the Sun, it is 1000's of times more luminous than the sun, so it is consuming its fuel 1000's of times faster. So its lifetime is much shorter than that of the Sun.

5. We know in detail which elements the Sun contains and about how much of each one. How do we know this?

   - Each element emits and/or absorbs radiation at a specific wavelength, producing spectral lines. By measuring the wavelength and intensity of these lines, we can measure how much of each element is in the sun.

6. On a Color-Magnitude diagram (or H-R diagram), most stars are found to fall along a curved diagonal line from the upper left (bright and blue) to the lower right (dim and red). What do we call this line? What is the primary parameter that determines where a star falls on this line?

- This line is called the Main Sequence. It contains stars which are still fusing hydrogen.
- The star's mass determines where on the Main Sequence it falls.