Astro 102
Group Problems #3
2006-June-22

Useful Data

$$1\,\text{year} = 3.156 \times 10^7\,\text{seconds}$$
$$1\,\text{AU} = 1.496 \times 10^{11}\,\text{m}$$
$$1\,\text{pc} = 206,265\,\text{AU}$$

$$c = 3.00 \times 10^8\,\text{m}\,\text{s}^{-1}$$
$$\sigma = 5.67 \times 10^{-8}\,\text{W}\,\text{m}^{-2}\,\text{K}^{-4}$$

$$1\,\text{rad} = 206,265''$$
$$180^\circ = \pi\,\text{rad}$$

$$M_\odot = 1.99 \times 10^{30}\,\text{kg}$$
$$R_\odot = 6.97 \times 10^8\,\text{m}$$
$$L_\odot = 3.8 \times 10^{26}\,\text{J}\,\text{s}^{-1}$$
$$T_\odot = 5,800\,\text{K}$$

$$B = \frac{L}{4\pi\, d^2}$$
$$L = (4\pi\, R^2)\,(\sigma T^4)$$

$$d = \frac{1}{p} \qquad A = \frac{h}{d}$$

1. Suppose you are measuring distances to stars using parallax, and using the Hubble Space Telescope (HST) to measure that parallax. The HST as a resolution (minimum angular separation detectable) of about $0.05''$.

(a) What is the distance to a star whose parallax can just barely be measured by the HST?

(b) Can the HST only measure parallaxes which are *greater than or equal to* the parallax of the star in (a), or which are *less than or equal to* the parallax of the star in (a)?

2. The star Betelgeuse has a measured parallax of $0.0076''$. It has a measured angular size of about $0.06''$. Physically, how big is Betelegeuse compared to the Sun? (I.e. what is the diameter of Betelegeuse in "Sun diameters", or equivalently, what is the ratio of Betelgeuse's true diameter to the Sun's true diameter?) How big is Betelgeuse compared to Earth's orbit around the Sun?

3. You observe a binary system. Star 1 is a bright main sequence B-star with a surface temperature of 15,000 K. It is an unusual star whose spectrum shows emission lines as well as a blackbody. Star 2 is a red giant, a K-star with a surface temperature of 4,000 K, and has a more usual absorption line spectrum. Both stars appear equally bright.

On the axes below, plot two spectra, one for Star 1, one for Star 2. Clearly label your plot. Don't worry about the exact wavelengths of specific features, but make sure that the overall spectra are plotted relatively right.

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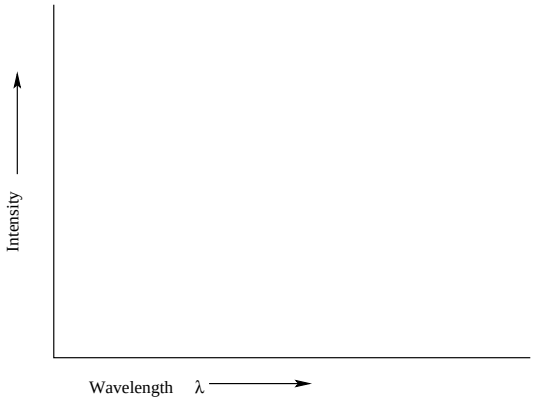


4. Star 2 from the previous problem is 5,000 times as luminous as the Sun. From Earth, the Sun appears 8.5×10^9 (that's 8.5 billion) times brighter than Star 2.

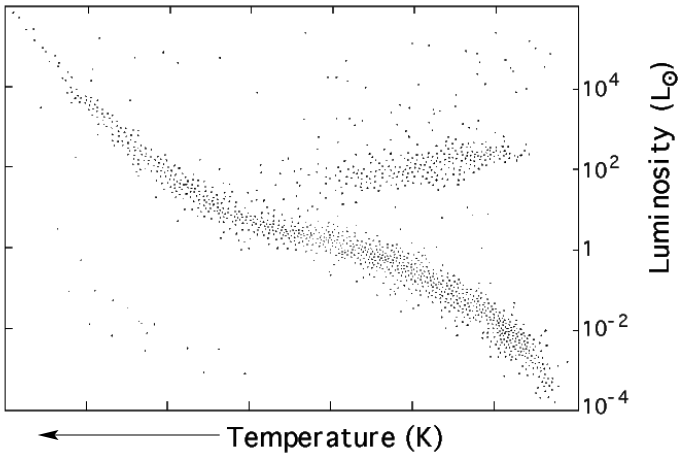
(a) How far away is Star 2?

(b) What is the radius of Star 2 in $R_\odot$? (That is, what is the ratio of the radius of Star 2 to the ratio of the Sun.) Does your answer sound reasonable, knowing the type of star that Star 2 is?

5. **(a)** Plot Star 1 and Star 2 from the previous two problems on the H-R Diagram below; label the points you plot.

(b) Star 3 is another star, not part of the binary, that has the same color and luminosity as Star 2, but is 100 times farther away. Plot it on the H-R Diagram, and label the point.

(c) Star 4 is another star which has the same color as Star 2; it is only 1/400th the size of Star 2, but it is also only 1/400th as far away. Plot it on the H-R diagram, and label the point.



6. What is the ratio of the brightness of the Sun to the brightness of Star 2 (from the previous three problems) as measured by an observer near Jupiter (5.2 AU away from the Sun)?