

Student Name:

Lab TA Name:

## A1101, Lab 5: The Hertzsprung-Russell Diagram Take Home Worksheet

This take-home assignment is due at the beginning of Lab 6.

### Recap of Key Concepts from Lab 5

The *luminosity* of a star is the rate at which it radiates energy into space.

The *brightness* of a star (a.k.a. *apparent brightness* or *flux*) describes the rate at which we on Earth receive energy from the star.

They are related by

$$\text{Luminosity} = \text{Brightness} \times (4\pi d^2)$$

where  $d$  is the distance to the star.

The *color index* of a star is a quantitative measure of its color. Larger color indices mean redder colors. The color of a star is determined mainly by the *temperature* of its surface. Hotter stars are bluer, cooler stars are redder.

The luminosity of a star depends on its temperature and its surface area. For stars of the same temperature, the luminosity is proportional to surface area: a star that is twice as big in radius has four times higher luminosity (because the surface area of a sphere is  $4\pi r^2$ )

A Hertzsprung-Russell diagram is a graph of luminosity vs. color index (or some other indicator of surface temperature) for a population of stars.

### Questions

Figure 1 on the attached page shows the HR diagram that you were given in class. Figure 2 shows the same stars, but here what's plotted is the apparent *brightness* of the star as seen from the Earth, instead of the luminosity. The vertical axis is scaled so that 1.0 represents the brightness of  $\alpha$  Centauri. Although there are stars brighter than  $\alpha$  Centauri in the sky, this graph shows only a fraction of the stars in the Hipparcos catalog, which is why there are no stars above 1.0 in the graph.

1. Suppose that you have used a digital camera and filters to measure the brightness and color index of a lot of stars. You therefore have the information needed to plot a graph like Figure 2. What additional measurements would you need to make before you could plot a graph like Figure 1? Would making these additional measurements be easy or hard? Explain your answer.

2. Explain why Figures 1 and 2 look different. (Don't just say how they look different, give a 1-3 sentence explanation of why the points have such different distributions in the two diagrams.)

3. If you want to learn about how stars work, which of these diagrams, Figure 1 or Figure 2, would be more useful? Explain your answer.

Figure 3 shows an HR diagram for the 200 stars in the Hipparcos parallax catalog (i.e., stars with parallaxes measured by the Hipparcos space mission) that are closest to the Earth, within about 30 light years.

Figure 4 shows an HR diagram for the 200 brightest stars in the Hipparcos catalog, i.e. the 200 stars that appear brightest as seen from Earth.

4. Explain why Figure 3 and Figure 4 look so different. (Hint: Think about how the distance to a star and the luminosity of a star affect its brightness.)

5. Based on thinking carefully about Figures 3 and 4, which kind of star do you think is more common throughout the Milky Way galaxy:

A. Stars with luminosity less than 0.001 solar luminosities.

B. Stars with luminosity greater than 1000 solar luminosities.

Explain the reasoning behind your answer.

Figure 1

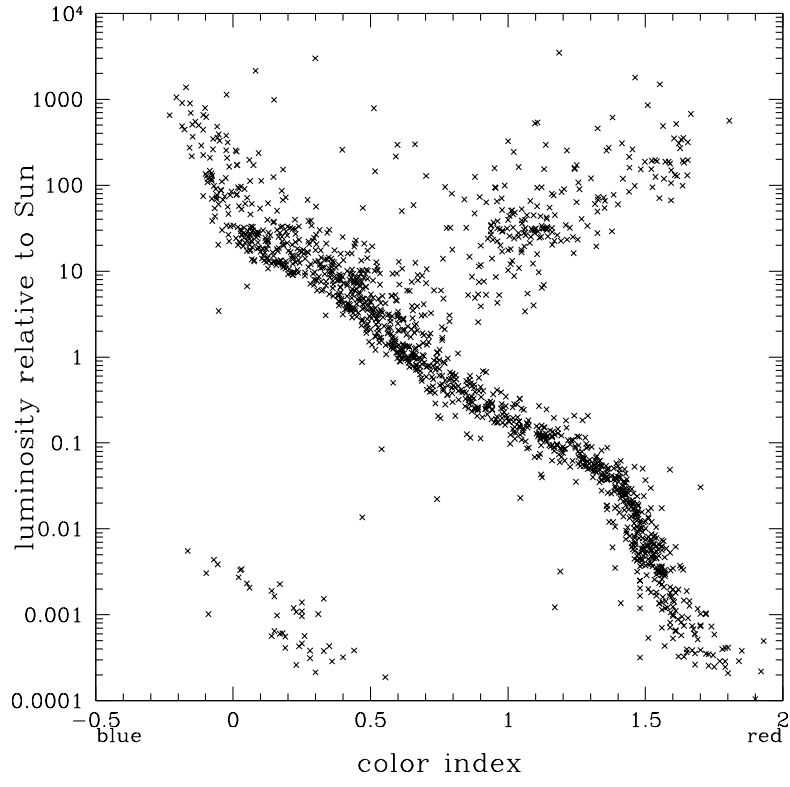


Figure 2

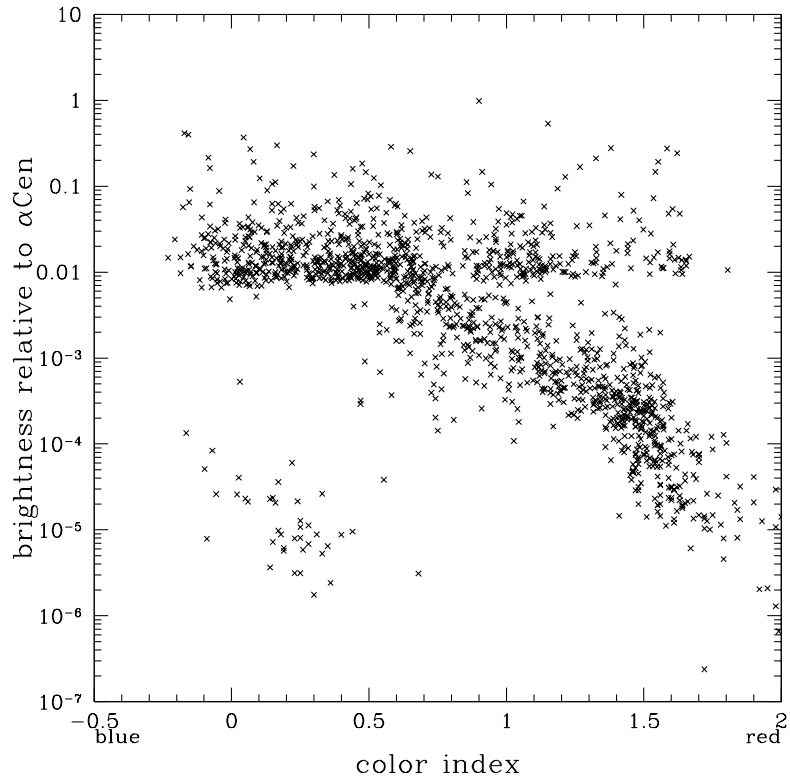


Figure 3

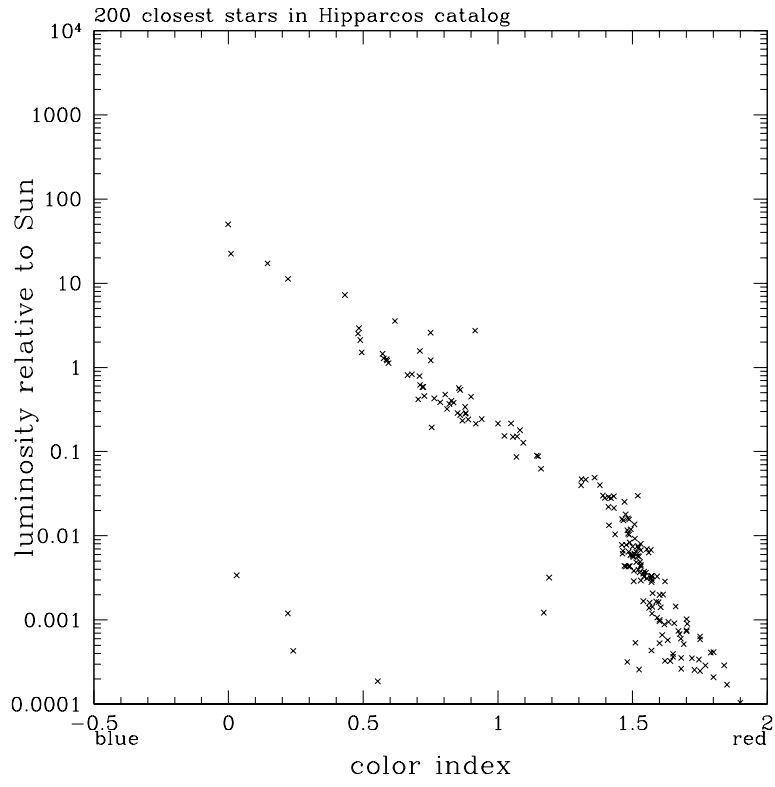


Figure 4

