Lab #15: Magnitudes, the Hertzsprung-Russell Diagram, and Distances

The Hertzsprung-Russell diagram is an important tool in the study of stars. In the early 1900's the two astronomers investigated nearby stars and found a relationship between their color and brightness. This work lead to the important discovery that the brightness of a star is related to the temperature of its surface. In the typical HRD the absolute magnitude (brightness) is plotted against the spectral type (temperature *or* color) of a star. The HRD for this lab shows several different types of stars and their proper names, including the Sun.

Here are some important definitions for terms used in the lab:

Apparent magnitude – The measure of the brightness of a star as seen from Earth.

Absolute magnitude – The measure of the brightness of a star as it would be seen from the standard distance of 10 parsecs. A parsec (pc) is a unit of distance; 1 pc = 3.26 light years.

Spectral type – Indicates the color of the star, which is related to its surface temperature. From the hottest to coolest, and from blue to red color, the types are: O, B, A, F, G, K, M. A second number is added for finer classification, like G0, G1, G2, …, G9. A blue star is hotter than a yellow star, which is hotter than a red star.

The apparent magnitude of a star can be directly measured, because it indicates how bright the star looks in the sky. From the distance of *10 parsecs*, a star would look fainter or brighter than from Earth, depending on its actual distance. The difference between a star's absolute and apparent brightnesses tells its distance from us. The mathematical relationship is:

$$M = m + 5 - 5 \log d$$

where *log* is 10-based logarithm and

- M is the star's absolute brightness,
- m is the star's apparent brightness,
- d is the distance to the star in parsecs.

Using the HRD and other information, you will determine the distances to various stars and compare various stars with each other. Notice that you'll need to solve the above equation for d; to simplify matters we did it for you: $d = 10^{1+\frac{m-M}{5}}$.

The main sequence – The line on the HRD where most (but not all) stars are located. Main sequence stars "burn" hydrogen into helium to produce heat; giants burn helium into heavier elements; white dwarfs have no active source of heat in their cores any more.

PROCEDURE AND LAB REPORT

Date:_______ Your name: ___________Partner's name: ___________ Section: ___/___

Maximum two students may work together as partners!

1. Examine the HR diagram. Find the *spectral type* and *absolute magnitude* of the stars in the table. (Those not yet on the HRD will be filled in later.)

Name	Official name	Spectral type	Color	Distance (light years)	Absolute magnitude	Apparent magnitude
Sirius A	α Canis Maioris					-1.4
The Sun	-			ly = km		-27.0
Betelgeuse	α Orionis					
Rigel	β Orionis					0.3
Proxima	α Centauri C^2					11.7
Alcyone	η Tauri in the Pleiades					
Procyon	α Canis Minoris					
The G2 star in # 5	-					

2. Select the correct answer:

- Based on its position in the HRD, Proxima is. SELECT and SELECT .
- Based on its position in the HRD, Betelgeuse is SELECT and SELECT .
  That makes it a SELECT SELECT .
- Based on its position in the HRD, Rigel is. SELECT and SELECT .
  That makes it a SELECT SELECT
- Sirius is a double star. The very bright Sirius A is accompanied by a faint one, called Sirius B.
  Based on its position in the HRD, Sirius B is SELECT and SELECT .
  That makes it a SELECT SELECT

3. Use the formula relating the absolute and apparent magnitudes with the distance to determine how far Procyon (α Canis Minoris) is.

- Procyon's apparent magnitude is $m = 0.35$ *mg*, so it is a SELECT star.
- Its absolute magnitude is $M =$_____ *mg.* This means that from a distance of *10 parsecs* it would look SELECT than from Earth.
- This means that it must be SELECT than *10 parsecs*.
- Your solution of the equation is $d =$ _____ *parsecs*, which is indeed SELECT than *10 parsecs*. Convert the distance to Procyon to light years; d= _________ *light years*.

4. Use the above procedure to determine how far the following stars are:

- *Betelgeuse (m = 0.45 mg.)*
- *The Seven Sisters* (Alcyone, a *B4* main sequence star, is *m = 2.87 mg*).

Plot them in the HRD and fill in the table entries.

Answers: Betelgeuse: M = _____ *mg*, _____ *parsecs* = ______ *light years*,
Alcyone (in the Pleiades): M = _____ *mg*, _____ *parsecs* = ______ *light years*.

5. Suppose an observer finds a faint, *m = 13 mg* yellow main sequence star in the sky, similar to the Sun (spectral type G2). How far is it? _______ *parsecs* =______ *light years* .
Where is it on the HRD? In which part of the Galaxy can that star be?
This star will be SELECT
Recall that the Galaxy is *30,000 parsecs* in diameter.