ASTRO 1050
The Seven Sisters, and Lives of the Stars

ABSTRACT

There is a conspicuous nest of stars, or "star cluster", in the winter and spring sky called the Pleiades, or "Seven Sisters." By plotting a luminosity-temperature diagram, you will see which of these stars have already completed their lives as main sequence stars. This will tell you how long these stars have existed until now, and you can predict the future for the Pleiades.

Materials

Your brain and a computer

Excercises

On the next page is a photograph of the Pleiades take with a telescope. Stars #1-7 (the "Seven Sisters") have names, which originate in Greek mythology:

1. Merope

2. Alcyone

3. Electra

4. Taygeta

5. Maia

6. Calaeno

7. Pleione

If you have exceptional eyesight, you can see the seven brightest stars without a telescope; most people can only see five. To see the Pleiades in the fall, you need to look well after midnight. In the winter and spring, the group is high in the sky.

Fig. 1.—: HST image of the Pleiades

1. Using Table 1., plot an H-R diagram on the computer with Temperature on the horizontal axis and luminosity on the vertical axis. Your instructor will re- mind you how to plot a luminosity-temperature diagram; see Table 3 (towards the end of this lab) for information on the temperatures of different spectral types. Your plot should contain appropriate **axis labels, a chart label,** and **series labels**. After completing Part 2., have your group email your plot with each of your lab partners' names included.

Note: If you're not familiar with Excel, see the tips at the end of this lab and/or ask for help.

The following Table 1. shows the luminosities and spectral types of 24 stars in the Pleiades cluster:

Table 1:: Stars in the Pleiades

Star	Solar Luminosity	Spectral Type	Star	Solar Luminosity	Spectral Type
Alcyone	1940	B7	G	19.0	A6
Electra	1150	B6	H	14.2	A5
Maia	1940	B8	I	9.20	F1
Merope	1340	B6	J	6.98	A9
Taygeta	929	B6	K	4.78	F2
Pleione	338	B8	L	3.43	F3
A	160	B9	M	3.05	F6
B	138	B9	N	2.11	F6
C	105	B9	O	1.43	F8
D	52.4	A1	P	1.18	G2
E	35.6	A5	Q	0.87	G6
F	25.6	A3	R	0.67	G6

Table 2:: Main Sequence Stars

Spectral Type	Solar Luminosity
B0	2000
B5	794
A0	79.4
A5	20.0
F0	6.31
F5	2.51
G0	1.26
G5	0.79
K0	0.40

2. Add to your plot the Main Sequence stars (Table 2.) as a different series. Then add a line that approximately follows where the main sequence stars from Table 2. "should be."

3. Compare the luminosities and temperatures of the Pleiades stars to those of the main sequence. Determine from your own results which of the Pleiades stars no longer appear to be main sequence stars and list their names, explaining why you conclude they are not main sequence stars.

4. Main sequence lifetimes:

   - Type O5 survives on the Main Sequence for 1 million years
   - Type B0 for 11 million years
   - Type A0 for 440 million years
   - Type F0 for 3000 million years (3 billion years).

   Intermediate types have intermediate ages, meaning that if the star type is between O and B the age is also between 1 million years and 11 million years. Study your diagram and decide which one of the Pleiades stars most recently ceased to be a main sequence star. Using the information above, estimate how long this star has existed, and explain your estimate. (Because all of the Pleiades stars were born together, at the same time, your answer is also the current age of the entire cluster. Cool right?)

5. A type B7 like Alcyone will end its stellar life by ejecting most of its mass into a planetary nebula. The remaining mass will collapse into a white dwarf. A white dwarf is a member of a class of objects called compact objects that also includes neutron stars and black holes.

Given that the density of a white dwarf is 10^9 kg/m^3 and that the density of neutron star is 10^{17} kg/m^3, determine how much a cubic **centimeter** of white dwarf and neutron star matter weighs (on Earth) in pounds. (1 kg $= 2.2$ lb, here on Earth) In other words, **convert both the white dwarf and neutron star from kg/m^3 $\rightarrow$ lb/cm^3.**

6. When stars get brighter than type B0, they end their lives in huge explosions known as supernovae. Neutron stars or black holes are the remnant that is left after this event.

The radius of a black hole is related to its mass by the formula:

$$R = \frac{2GM}{c^2} \tag{1}$$

where,
G $= 6.674 \times 10^{-11}$ m^3/kg/s^2
c $= 2.998 \times 10^8$ m/s

Given the mass of earth is 5.973×10^{24} kg, determine its radius if it collapses into a black hole. Do the same for Rigel, which is 18 solar masses (solar mass is 1.99×10^{30} kg).

Table 3:

Spectral Type	Temperature (K)	Spectral Type	Temperature (K)
O5	54,000	F5	6,700
O6	45,000	F6	6,550
O7	43,300	F7	6,400
O8	40,600	F8	6,300
O9	37,800	G0	5,930
B0	29,200	G2	5,800
B1	23,000	G5	5,660
B2	21,000	G8	5,440
B3	17,600	K0	5,240
B5	15,200	K1	5,110
B6	14,300	K2	4,960
B7	13,500	K3	4,800
B8	12,300	K4	4,600
B9	11,400	K5	4,400
A0	9,600	K7	4,000
A1	9,330	M0	3,750
A2	9,040	M1	3,700
A3	8,750	M2	3,600
A4	8,480	M3	3,500
A5	8,310	M4	3,400
A7	7,920	M5	3,200
F0	7,350	M6	3,100
F2	7,050	M7	2,900
F3	6,850	M8	2,700

Note: If a spectral type is missing, go ahead and average

Excel Tips

1. **Add your numbers your Excel spreadsheet** by selecting a cell and typing in the numbers. You should make a column of temperatures and a column of luminosities to its right. Not all spectral types are represented in the table, so interpolate between numbers when necessary.

2. **Make a chart of your Pleiades data:**

   (a) Click on the first temperature, followed by the last luminosity (i.e. the upper left and lower right of the block of numbers you want in your plot) while holding shift. The column on the left will go on the x axis.

   (b) Select "Insert" tab and click the "XY Scatter" plot.

   (c) Click on plot and double click the x axis, then click the box "values in reverse order" to plot higher temperatures on the left (as we do in an HR diagram).

3. **Add labels to your plot:**

   (a) Select the Layout tab

   (b) Select the Add Chart Title and Axis Titles buttons in the Layout toolbar to add those titles, respectively.

   (c) Once you have added the titles to your plot, you can edit them by clicking on the title box on the plot, deleting the default words and adding your own.

4. **Add the main sequence to your plot:**

   (a) Click "Design" chart tab.

   (b) Click the "Select Data" button in the "Design" toolbar.

   (c) Click "add" or "+" in the legend entries to add a new series.

   (d) Select the "Select X values:" box, then click the first cell in you want on your x axis, hold down shift, and select the last one.

   (e) Do the same for the y axis, but remove the "={1}" first.

   (f) Choose an appropriate series name, something like "MS" or "Main Sequence".

   (g) You can edit the series name for your original Pleiades data here as well. After you have finished editing your MS data, simply select "Series 1", click "Edit", and enter a new name for that series, like "Pleides".

5. **Connect the MS data points in a line:**

   (a) Click on the MS data in your plot.

   (b) In the "Design" tab, click "Change Chart Type" and choose a scatter plot with a connecting line. This will connect only the MS data points. This is reasonable because we know the MS follows a line. Do not connect your Pleiades data points, since technically we only know luminosity and temperature for the specific points you have already plotted.