

The H-R Diagram

•Materials

Computer Program: Microsoft Excel or equivalent

•Introduction

The purpose of this lab is to give you a hands (and computer) on experience with the Hertzsprung-Russell, or H-R diagram. A simple review of its characteristics will be given. For more information, please consult your textbook. A basic knowledge of Microsoft Excel is helpful.

•Basics: the H-R diagram

The H-R diagram is a plot of the **absolute** magnitudes of stars, M , versus their spectral type. Sometimes you will see the y axis in units of solar luminosity, L_{\odot} . Luminosity is directly proportional to absolute magnitude, and in this lab, we will use the absolute magnitudes of stars. Remember, the more negative an absolute magnitude, the BRIGHTER the star. We will also be using the **apparent** magnitude, m , of stars. The apparent magnitude refers to how bright a star appears to us on Earth.

The x axis, spectral type, is a measure of a star's surface temperature. Astronomers label spectral type with integers and letters, ranging from M10 (cool, red), to O0 (hot, blue). Note that a M7 type star is cooler than a M0 star, and that the order of letters from cool to hot is: M, K, G, F, A, B, O. The Sun is a G2 star with surface temperature of about 5800 K.

•Basics: Luminosity classes

In addition to classifying stars into spectral types, we group them into luminosity classes. A star with the temperature 5800 K might be a very luminous star (one with a negative value of M), or a dim star (large, positive M). Astronomers give groups of stars with similar luminosities special names.

For example, the brightest stars are called luminous supergiants and are labeled with the luminosity class Ia. The Sun is a main sequence star, class V. See the chart below for additional information.

Luminosity Class	Star Type
Ia	luminous supergiants
Ib	less luminous supergiants
II	bright giants
III	giants
IV	subgiants
V	main sequence

•Basics: Plotting and using Excel

Here are some tips and hints for plotting your data in Excel. The intent of these hints is not to teach you how to use Excel. If you have questions, see your instructor:

- 1) Convert your x axis values to numbers. For example, set B=0, A=1, etc. Then you can use G2=3.2, or K1=4.1, and so on.
- 2) In Excel, punch in your numbers for your x and y axis.
- 3) Make a scatter plot, including axis labels.
- 4) To get the correct y axis, with negative values at the top, click on the y axis in the plot you've already created. Go to "Format", "Selected axis", "Scale" tab. At the bottom, click "values in reverse order."
See your lab TA if you have questions.

•Create your H-R diagrams

A) Main Sequence Stars

Plot, in Excel or another graphing program, the stars in Table A. The curve that approximately connects these points is the main sequence; most stars lie on this line. As mentioned earlier, the main sequence stars are luminosity class V stars. Make a label in your plot that indicates this fact.

B) Giant Stars

Now plot the stars in Table B on the same diagram. These are giant stars, luminosity class III.

C) The Brightest stars in the sky

In a new diagram, plot all of the stars from Table A and Table C. In Table C, the roman numerals refer to the luminosity class, as in the table above. " M " is absolute magnitude, and " m " is apparent magnitude.

D) The Nearest stars in the sky

In another new diagram, plot all of the stars in Table D.

Table A

Star	Type	M
Sun	G2	+5.0
σ Per A	B0	-3.7
γ Cet	A2	+2.0
α Hyi	F0	+2.9
Kruger 60B	M6	+13.2
Procyon A	F5	+2.7
δ Cyg A	K5	+7.5
τ Cet	G8	+5.7
α Gru	B5	+0.3
Kapteyn's Star	M0	+10.8

Table B

Star	Type	M
Arcturus	K2	-0.3
Capella	G2	+0.0
Aldebaran	K5	-0.7
Pollux	K0	+1.0

Table C

Star	Type	M	m
Sirius	A1V	1.5	-1.4
Canopus	F0Ib	-4.0	-0.7
Rigel Kentaurus	G2V	4.4	-0.3
Arcturus	K2III	-0.3	-0.1
Vega	A0V	0.5	0.0
Capella	G2III	0.0	0.1
Rigel	B8Ia	-7.1	0.1
Procyon	F5IV	2.7	0.4
Betelgeuse	M2Ia	-5.6	0.4
Achernar	B5IV	-3.0	0.5
Hadar	B1II	-3.0	0.6
Altair	A7IV	2.3	0.8
Acrux	B1IV	-3.9	0.8
Aldebaran	K5III	-0.7	0.9
Antares	M1Ib	-3.0	0.9
Spica	B1V	-2.0	0.9
Pollux	K0III	1.0	1.2
Fomalhaut	A3V	2.0	1.2
Deneb	A2Ia	-7.1	1.3
Beta Crucis	B0III	-4.6	1.3
Regulus	B7V	-0.6	1.4
Adhara	B2II	-5.1	1.5
Castor	A1V	0.9	1.6
Shaula	B1V	-3.3	1.6
Bellatrix	B2III	-2.0	1.6
Elnath	B7III	-3.2	1.7
Miaplacidus	A0III	-0.4	1.7
Alnilam	B0Ia	-6.8	1.7

•Questions

Answer the following questions on a separate piece of paper. For credit, turn your answers and your plots.

1. Why don't the stars in Table B lie on the curve you created in part A) ?
2. How many magnitudes is Capella brighter than the Sun?
3. How many times brighter is Capella than the Sun?
4. Is Capella larger or smaller than the Sun?
5. What is the most common kind of **bright** (M) star (hot, cool, or spectral type)?
6. Estimate the average **apparent** magnitude, m , of the brightest stars (Table C).
7. When you look at a bright star in the sky, your probably looking at what spectral type of star?
8. What is the most common kind of star near the Sun?
9. Estimate the average **apparent** magnitude of the close stars (Table D).
10. We believe the stars near the sun are ordinary, common stars. Why don't we see mostly common stars?
11. What would our night sky look like if all the stars in the galaxy had the same **absolute** magnitude as the Sun?
12. Write a short summary of what you learned in the lab.

Table D

Star	Type	M	m
Sun	G2	4.8	-26.8
Proxima Centauri	M5	15.4	0.1
Alpha Centauri A	G2	4.4	1.5
Alpha Centauri B	K5	5.8	11.0
Barnard's Star	M5	13.2	9.5
Wolf 359	M6	16.7	13.5
Lalande 21185	M2	10.5	7.5
Sirius A	A1	1.5	-1.4
Luyten 726-8A	M6	15.3	12.5
Luyten 726-8B	M6	15.8	13.0
Ross 154	M5	13.3	10.6
Epsilon Eridani	K2	6.1	3.7
Luyten 789-6	M6	14.6	12.2
Ross 128	M5	13.5	11.1
61 Cygni A	K5	7.5	5.2
61 Cygni B	K7	8.3	6.0
Epsilon Indi	K5	7.0	4.7
Procyon A	F5	2.7	0.3
Cincinnati 2456A	M4	11.2	8.9
Cincinnati 2456B	M4	12.0	9.7
Groombridge 34A	M1	10.4	8.1
Groombridge 34B	M6	13.3	11.0
Lacaille 9352	M2	9.6	7.4
Tau Ceti	G8	5.7	3.5
Luyten's Star	M4	11.9	9.8
Lacaille 8760	M1	8.8	6.7
Kapteyn's Star	M0	10.8	8.8
Kruger 60A	M4	11.7	9.7
Kruger 60B	M6	13.2	11.2