

## Exercise 5: Constructing an H-R Diagram

Astro 102, Winter 2012

**Due 11/2**

### Introduction

We like to believe that our vantage point of the sky is typical; that is, we see a representative sample of all types of stars. One way to find out is to compare the aggregate properties of a vast sample of stars throughout a large volume to a very local population of stars. Your first goal is to plot a set of the 40 nearest stars and another set of the 40 brightest stars in the sky on the H-R diagram and to investigate (1) which sample is probably the most representative, and (2) to explain any blatant differences between the two samples. You will be exploring the concept of “sample bias” (aka “sample selection bias”) or, in other words, whether the way in which you chose a sample influences your conclusions. Your second goal is to determine whether a huge precision survey of 22,000 stars that obtained accurate distances (and, hence stellar luminosities) is free of such bias and, if not, then to guess why not.

Suppose you're a demographer and you're interested in the age distribution of people in the U.S. Would you pick a random sample of students at U.W.? Obviously not: most of the people on our campus are “selected” by ages (typically 17-23). Would you go to a hospital? A ball game? A department store? An airport? You have to be very careful in this effort to avoid sample bias. *How you would find an unbiased sample of peoples' ages?*

Suppose that you want to determine the demographics of stellar masses. More precisely, how many stars are found in various mass groups? We will assume that the mass of any star on the Main Sequence (MS) is known accurately. So all we need to do is to find a representative sample of stars, plot them as points on the MS, and then count the stars that are (say)  $0.5$  to  $1M_{\odot}$ ,  $1$  to  $1.5 M_{\odot}$ ,  $1.5$  to  $2 M_{\odot}$ ,  $2$  to  $2.5 M_{\odot}$ , etc. Sounds easy, doesn't it? The trick is to find an unbiased sample of stars to plot. We'll try making an H-R diagram of the 40 brightest stars since measuring their colors and brightness is simplest. Then we'll try the 40 nearest.

Perhaps a sample of 40 stars isn't good enough for measuring any of the properties of typical stars. So we'll consider an H-R diagram measured by a precision satellite that found brightnesses, luminosities, and colors for over 20,000 stars within a particular volume of space chosen at random. We'll simply compare the various H-R diagrams, see how they differ (and why), and then decide which of your samples is the better one for characterizing the general properties of stars.

### Need to review the H-R Diagram?

Go to [http://www.astro.washington.edu/users/balick/astro102/assignments/TuG\\_hrdiagram.pdf](http://www.astro.washington.edu/users/balick/astro102/assignments/TuG_hrdiagram.pdf)

### Methodology

The luminosities  $L$  (in solar units) and temperatures  $T$  (in degrees Kelvin) (and the equivalent spectral type) of the nearest and the brightest stars are provided in two tables below. From these you'll construct two H-R diagrams, one for each sample. Then you'll compare these plots to the larger sample shown below. You'll make a critical judgment about which of your samples (nearest and brightest) is best for stellar mass demographics, and explain your reasons.

### What to Turn In

Your task for today (to be completed before you leave) is for your lab partner and you to plot the data for the nearest stars on one plot. Do the brightest stars on a second plot. *When you finish the plots ask your TA to check them so that your followup work at home is productive!*

Then complete the section below called “Data Analysis and Results” at home. You'll need the plots that you made in class. Remember, all submitted work must be written in your own words.

The next two pages contain the requisite data for the plots.

**The Brightest Stars** (do not turn in)

$\text{Log}(L/L_{\odot})$  is the logarithm of the star's luminosity in solar units. (Ignore  $M(V)$ .)

Star	$M(V)$	$\text{log}(L/L_{\text{sun}})$	Temp	Type	Star	$M(V)$	$\text{log}(L/L_{\text{sun}})$	Temp	Type
Sun	4.8	0.00	5840	G2	Sirius A	1.4	1.34	9620	A1
Canopus	-3.1	3.15	7400	F0	Arcturus	-0.4	2.04	4590	K2
Alpha Centauri A	4.3	0.18	5840	G2	Vega	0.5	1.72	9900	A0
Capella	-0.6	2.15	5150	G8	Rigel	-7.2	4.76	12140	B8
Procyon A	2.6	0.88	6580	F5	Betelgeuse	-5.7	4.16	3200	M2
Achemar	-2.4	2.84	20500	B3	Hadar	-5.3	4.00	25500	B1
Altair	2.2	1.00	8060	A7	Aldebaran	-0.8	2.20	4130	K5
Spica	-3.4	3.24	25500	B1	Antares	-5.2	3.96	3340	M1
Fomalhaut	2.0	1.11	9060	A3	Pollux	1.0	1.52	4900	K0
Deneb	-7.2	4.76	9340	A2	Beta Crucis	-4.7	3.76	28000	B0
Regulus	-0.8	2.20	13260	B7	Acrux	-4.0	3.48	28000	B0
Adhara	-5.2	3.96	23000	B2	Shaula	-3.4	3.24	25500	B1
Bellatrix	-4.3	3.60	23000	B2	Castor	1.2	1.42	9620	A1
Gacrux	-0.5	2.10	3750	M3	Beta Centauri	-5.1	3.94	25500	B1
Alpha Centauri B	5.8	-0.42	4730	K1	Al Na'ir	-1.1	2.34	15550	B5
Miaplacidus	-0.6	2.14	9300	A0	Elnath	-1.6	2.54	12400	B7
Alnilam	-6.2	4.38	26950	B0	Mirfak	-4.6	3.74	7700	F5
Alnitak	-5.9	4.26	33600	O9	Dubhe	0.2	1.82	4900	K0
Alioth	0.4	1.74	9900	A0	Peacock	-2.3	2.82	20500	B3
Kaus Australis	-0.3	2.02	11000	B9	Theta Scorpil	-5.6	4.14	7400	F0
Atria	-0.1	1.94	4590	K2	Alkaid	-1.7	2.58	20500	B3
Alpha Crucis B	-3.3	3.22	20500	B3	Avior	-2.1	2.74	4900	K0
Delta Canis Majoris	-8.0	5.10	6100	F8	Alhena	0.0	1.90	9900	A0
Menkalinan	0.6	1.66	9340	A2	Polaris	-4.6	3.74	6100	F8
Mirzam	-4.8	3.82	25500	B1	Delta Vulpeculae	0.6	1.66	9900	A0

### The Nearest Stars *(do not turn in)*

Log(L/L<sub>☉</sub>) is the logarithm of the star's luminosity in solar units. (Ignore *M(V)*.)

<i>Star</i>	<i>M(V)</i>	<i>log(L/L<sub>sun</sub>)</i>	<i>Temp</i>	<i>Type</i>	<i>Star</i>	<i>M(V)</i>	<i>log(L/L<sub>sun</sub>)</i>	<i>Temp</i>	<i>Type</i>
Sun	4.8	0.00	5840	G2	*Proxima Centauri	15.5	-4.29	2670	M5.5
*Alpha Centauri A	4.3	0.18	5840	G2	*Alpha Centauri B	5.8	-0.42	4900	K1
Barnard's Star	13.2	-3.39	2800	M4	Wolf 359 (CN Leo)	16.7	-4.76	2670	M6
HD 93735	10.5	-2.30	3200	M2	*L726-8 ( A)	15.5	-4.28	2670	M6
*UV Ceti (B)	16.0	-4.48	2670	M6	*Sirius A	1.4	1.34	9620	A1
*Sirius B	11.2	-2.58	14800	DA	Ross 154	13.1	-3.36	2800	M4
Ross 248	14.8	-4.01	2670	M5	Epsilon Eridani	6.1	-0.56	4590	K2
Ross 128	13.5	-3.49	2800	M4	L 789-6	14.5	-3.90	2670	M6
*GX Andromedae	10.4	-2.26	3340	M1	*GQ Andromedae	13.4	-3.45	2670	M4
Epsilon Indi	7.0	-0.90	4130	K3	*61 Cygni A	7.6	-1.12	4130	K3
*61 Cygni B	8.4	-1.45	3870	K5	*Struve 2398 A	11.2	-2.56	3070	M3
*Struve 2398 B	11.9	-2.88	2940	M4	Tau Ceti	5.7	-0.39	5150	G8
*Procyon A	2.6	0.88	6600	F5	*Procyon B	13.0	-3.30	9700	DF
Lacaille 9352	9.6	-1.93	3340	M1	G51-15	17.0	-4.91	2500	M7
YZ Ceti	14.1	-3.75	2670	M5	BD +051668	11.9	-2.88	2800	M4
Lacaille 8760	8.7	-1.60	3340	K5.5	Kapteyn's Star	10.9	-2.45	3480	M0
*Kruger 60 A	11.9	-2.85	2940	M3.5	*Kruger 60 B	13.3	-3.42	2670	M5
BD -124523	12.1	-2.93	2940	M3.5	Ross 614 A	13.1	-3.35	2800	M4
Wolf 424 A	15.0	-4.09	2670	M5	van Maanen's Star	14.2	-3.78	13000	DB
TZ Arietis	14.0	-3.70	2800	M4	HD 225213	10.3	-2.23	3200	M22
Altair	2.2	1.00	8060	A7	AD Leonis	11.0	-2.50	2940	M3.5
*40 Eridani A	6.0	-0.50	4900	K1	*40 Eridani B	11.1	-2.54	10000	DA
*40 Eridani C	12.8	-3.20	2940	M3.5	*70 Ophiuchi A	5.8	-0.40	4950	K0
*70 Ophiuchi B	7.5	-1.12	3870	K5	EV Lacertae	11.7	-2.78	2800	M4

Once you're finished making your two plots, ask your TA to take a look in order to make sure that you're well along the road to success.