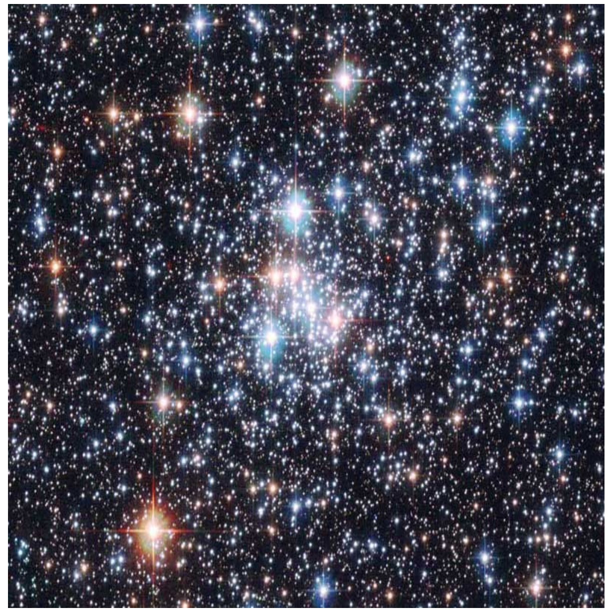
Stellar Lives

Introduction



Look up at the night sky around sunset. The first things that are obvious are the moon (if it is up at night and not during the day), and any bright planets that are out. As the night deepens, a bright star may appear. Then another, and another, until finally a myriad of bright and dim stars are seen. Within the city limits, most of the stars you see are actually pretty bright. But go out into the countryside, and after a while you will find that the number of stars you can see is so great that it even becomes difficult to find the familiar constellations. And those are only the stars that you can *see*.

Looking up at the stars, we can immediately see a few things that are different about them: apparent brightness and color. What might cause differences between stars? The apparent brightness we see depends on how far away the star is, and how *intrinsically* bright the star is.

We want to tie an observational property to something physical. We already know that color and temperature of a star are related, through the blackbody spectrum. We might think that a star's brightness can be tied to its physical size (the bigger something is, the brighter it will be). There's a sneaky assumption in there, though – that the energy per area is the same. That's not necessarily true, though. Both the *size* and the *temperature* of a star can affect its brightness, independent of each other. A small, hot star might put out more energy than a large cool star – or vice versa, depending on the exact sizes and temperatures.

How can we try to figure out what the stars in our galaxy are like? We could just make a list and order it by one property and see if anything makes sense. But humans are visual creatures. So often, it's easier to see trends on a graph with one thing plotted vs. the other. In this lab, we'll do just that: plot brightness vs. color to see if we find anything interesting. (Don't worry: we will. But you can imagine that lots of things were tried before we figured out this correlation.)

Before we go on, note that astronomy has some weird things in it. Since it developed from purely an observational perspective, sometimes people didn't know what things were and just named them. In this lab, we have a few weird things that are left over:

Magnitudes: these are just a measure of how bright a star is. The trouble is, when the Greeks looked up in the sky, they said "Hm, that star is bright. I will call that 1. That other star is next brightest, I will call that 2." The result is that the *brighter* the star, the *lower* the magnitude. Since we have telescopes now, some magnitudes even are negative numbers. **Absolute magnitude** corrects for the distance problem by pretending to put all the stars at a distance of 10 parsecs (this just because it makes the math easier for astronomers), so is a measure of how intrinsically bright the star is.

Stellar Classification: Going from hottest to coolest, the system runs as follows: O, B, A, F, G, K, M. You can remember the order by using the mnemonic: "Oh, be a fine guy (girl) kiss me." Within each letter, the stellar classification goes from 0 to 9 with 0 being hotter and 9 being cooler.

Luminosity Classification: This tells us what stage the star is in its life. Again the numbers (Roman numerals) are all out of order, because we didn't know that's what the groups were at first.

Lastly, here are a couple of useful tables:

Stellar Classification

Spectral Class	Temperature (K)	Star color
O	30,000 – 60,000	Blue
B	10,000 – 30,000	Whitish blue
A	7,500 – 10,000	White
F	6,000 – 7,500	Whitish yellow
G	5,500 – 6,000	Yellow
K	3,500 – 5,000	Orange
M	2,000 – 3,500	Red

Luminosity Classification

Luminosity Class	Stellar Type
0	Hypergiants
Ia	Brightest Supergiants
Ib	Supergiants
II	Bright Giants
III	Giants
IV	Subgiants
V	Main Sequence
VI	Subdwarfs
VII	White Dwarfs

Procedure:

1. Set up the graph:

   a) Draw the axes.
   b) Label the y-axis “Absolute Magnitude”. Use a range of **+20** on the **bottom** and **-10** on the **top**. This means that brighter stars are on the top.
   c) Label the x-axis “Spectral Class”. Use a range from **O5** on the left to **M6** on the right. This means that hotter stars are to the left and cooler stars are to the right.

2. Plot the Nearest Stars: **use an X to plot these stars**

   a) Plot Absolute Magnitude vs. Spectral Class.
   b) Be careful plotting magnitudes, remembering that -1.5 will be *above* -1.0 and 1.5 will be *below* 1.0.
   c) For spectral class, each letter has a range within it, with 0 on the left and 9 on the right. For example, an O9 star would be just to the left of a B0 star.

3. Plot the Brightest Stars: use an **O** to plot these stars **on the same graph**

4. Compare your plot with the HR-Diagram that was handed out. Identify the following groups of stars: Main Sequence, Red Giants, SuperGiants, White Dwarfs.

The 25 Nearest Stars

Name	Distance (light years)	Apparent Magnitude	Absolute Magnitude	Spectral Type
Sun	-	-26.72	4.8	G2 V
Proxima Centauri	4.2	11.05	15.5	M5.5 V
Alpha Centauri A	4.3	-0.01	4.4	G2 V
Alpha Centauri B	4.3	1.33	5.7	K1 V
Barnard's Star	6.0	9.54	13.2	M3.8 V
Wolf 359	7.7	13.53	16.7	M5.8 V
BD +36 2147	8.2	7.5	10.5	M2.1 V
Luyten 726-8A	8.4	12.52	15.5	M5.6 V
Luyten 726-8B	8.4	13.02	16.0	M5.6 V
Sirius A	8.6	-1.46	1.4	A1 V
Sirius B	8.6	8.3	11.2	A0 D
Ross 154	9.4	10.45	13.1	M3.6 V
Ross 248	10.4	12.29	14.8	M4.9 V
Epsilon Eri	10.8	3.73	6.1	K2 V
Ross 128	10.9	11.1	13.5	M4.1 V
61 Cygnus A	11.1	5.2	7.6	K3.5 V
61 Cygnus B	11.1	6.03	8.4	K4.7 V
Epsilon Ind	11.2	4.68	7.0	K3 V
BD +43 44 A	11.2	8.08	10.4	M1.3 V
BD +43 44 B	11.2	11.06	13.4	M3.8 V
Procyon A	11.4	0.38	2.6	F5 IV
Procyon B	11.4	10.7	13.0	F0 D
BD +59 1915 A	11.6	8.9	11.2	M3.0 V
BD +59 1915 B	11.6	9.69	11.9	M3.5 V
CoD -36 15693	11.7	7.35	9.6	M1.3 V

The 25 Brightest Stars

Name	Distance (light years)	Apparent Magnitude	Absolute Magnitude	Spectral Type
Sun	-	-26.72	4.8	G2 V
Sirius (A)	8.6	-1.46	1.4	A1 V
Canopus	310	-0.72	-5.5	F0 I
Alpha Centauri (A)	4.3	-0.27	4.4	G2 V
Arcturus	34	-0.04	0.2	K1.5 III
Vega	25	0.03	0.6	A0 V
Capella	41	0.08	0.4	G2 III
Rigel	~1400	0.12	-8.1	B8 I
Procyon (A)	11.4	0.38	2.6	F5 IV
Achernar	69	1.46	-1.3	B3 V
Betelgeuse	~1400	0.50	-7.2	M2 I
Hadar	320	0.61	-4.4	B1 III
α Crux	510	0.76	-4.6	B1 V
Altair	16	0.77	2.3	A7 V
Aldebaran	60	0.85	-0.3	K5 III
Antares	~520	0.96	-5.2	M1.5 I
Spica	220	0.98	-3.2	B1 V
Pollux	40	1.14	0.7	K0 III
Fomalhaut	22	1.16	2.0	A3 V
β Crux	460	1.25	-4.7	B0.5 III
Deneb	1500	1.25	-7.2	A2 I
Regulus	69	1.35	-0.3	B7 V
Adhara	570	1.50	-4.8	B2 II
Castor	49	1.57	0.5	A1 V
γ Crux	120	1.63 (var)	-1.2	M3.5 III