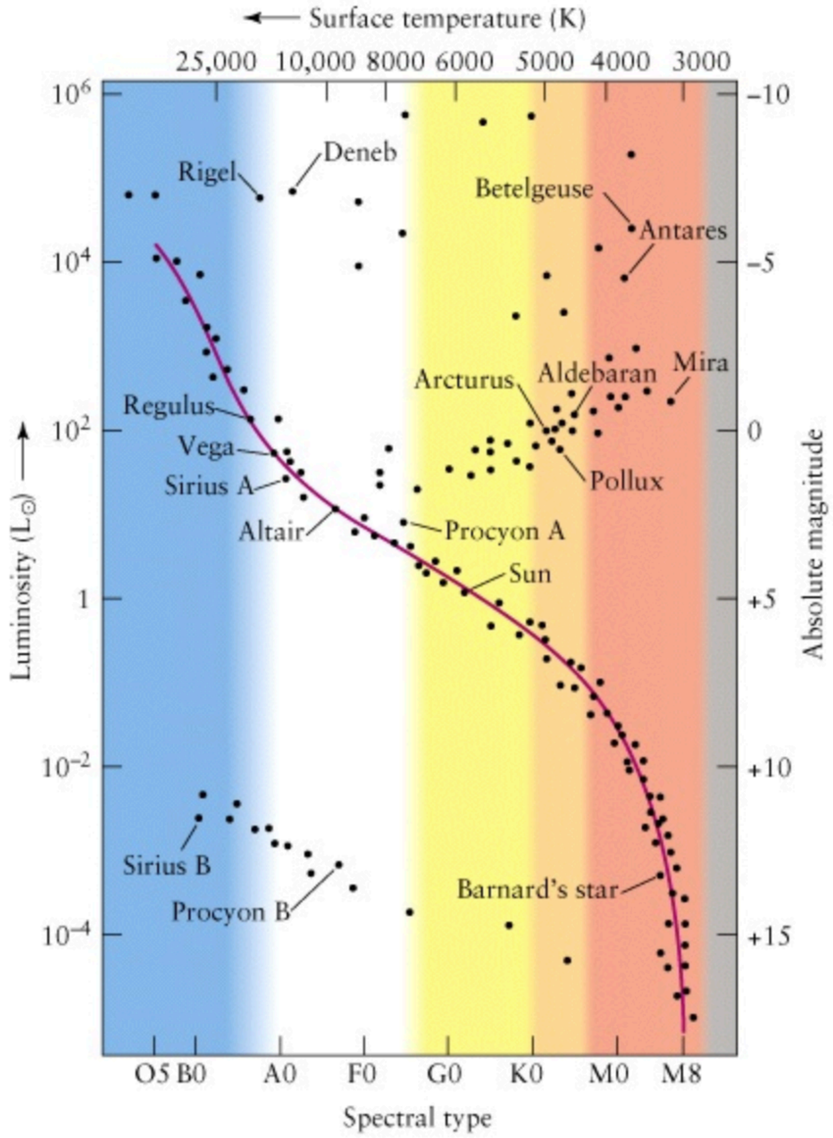
Name and Date:

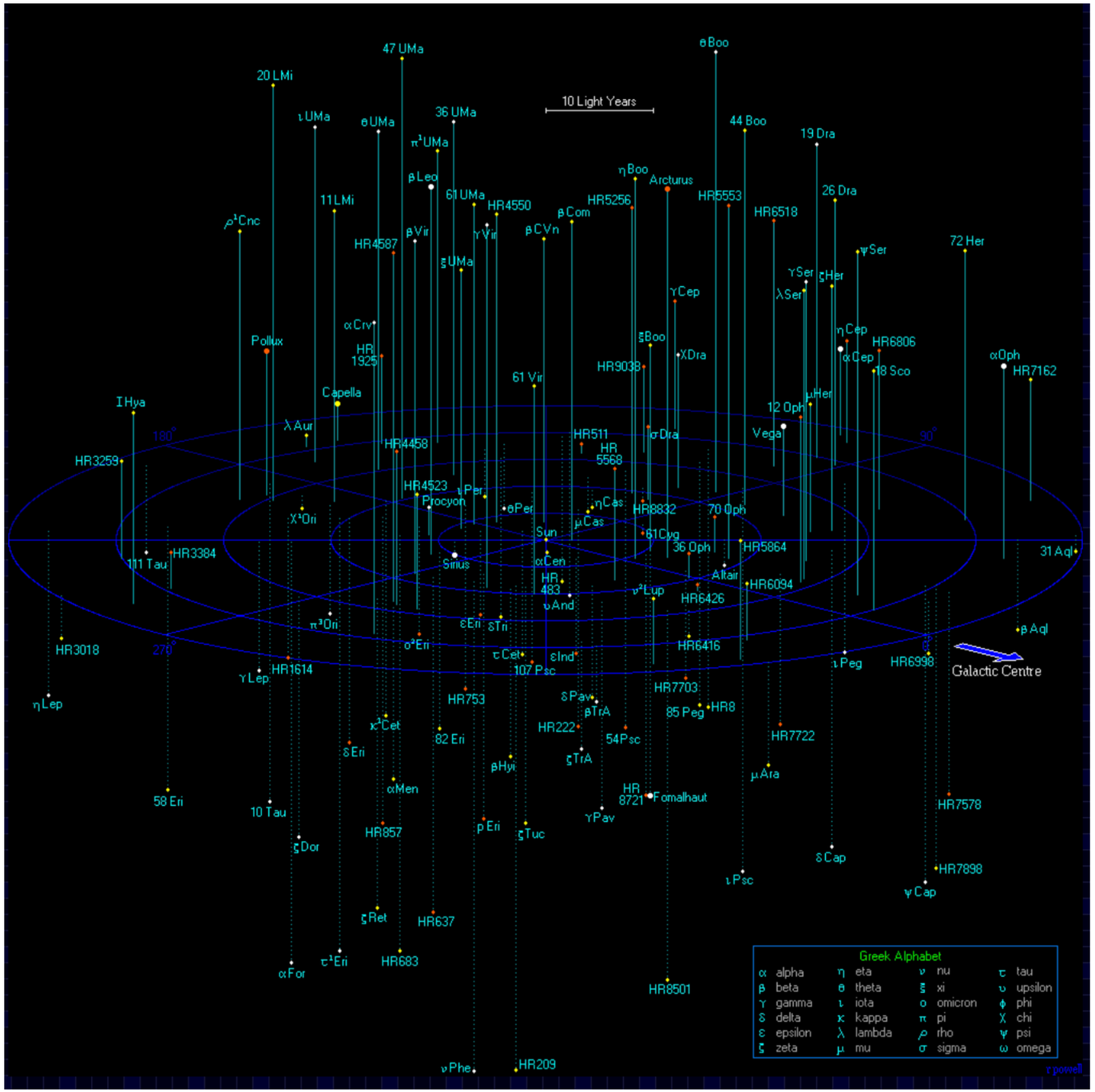
Astronomy 122
Homework 2: Hertzsprung-Russell Diagram (HR diagram)
Due: by the end of February 12, 2024

To the right is shown a Hertzprung-Russell (HR) Diagram. The HR diagram was developed in the 1910s credited to Ejnar Hertzprung and Henry Norris Russell with an early form used by Rosenberg. In theoretical HR diagrams, the Luminosity of a star is compared to its effective temperature. *Equivalently*, in its observational form, the absolute magnitude is compared to the spectral class (or color) of the star.

Here, we construct ***theoretical HR diagrams*** using samples of stars obtained in a couple of different ways. In this manner, we can infer some properties of stars based solely upon how they are distributed in an HR diagram.

There are, in fact, many other ways in which to sample stars allowing other features of stars to be inferred. The HR diagram was (and is) one of the most useful tools developed to explore the structure and evolution of stars.





I. At left are shown stars contained within a sphere of radius 50 light years surrounding the Earth, ***the Solar Neighborhood***.

The Earth is located at the center of the distribution.133 stars are shown. There are actually 2,000 systems in this sphere, roughly 10 % are shown (the brighter ones).

We are missing mainly red, low luminosity stars, red dwarfs from the sample.

Follow the link to find data similar to that used to make the plot on the previous slide a list of the brightest as seen from the Earth:

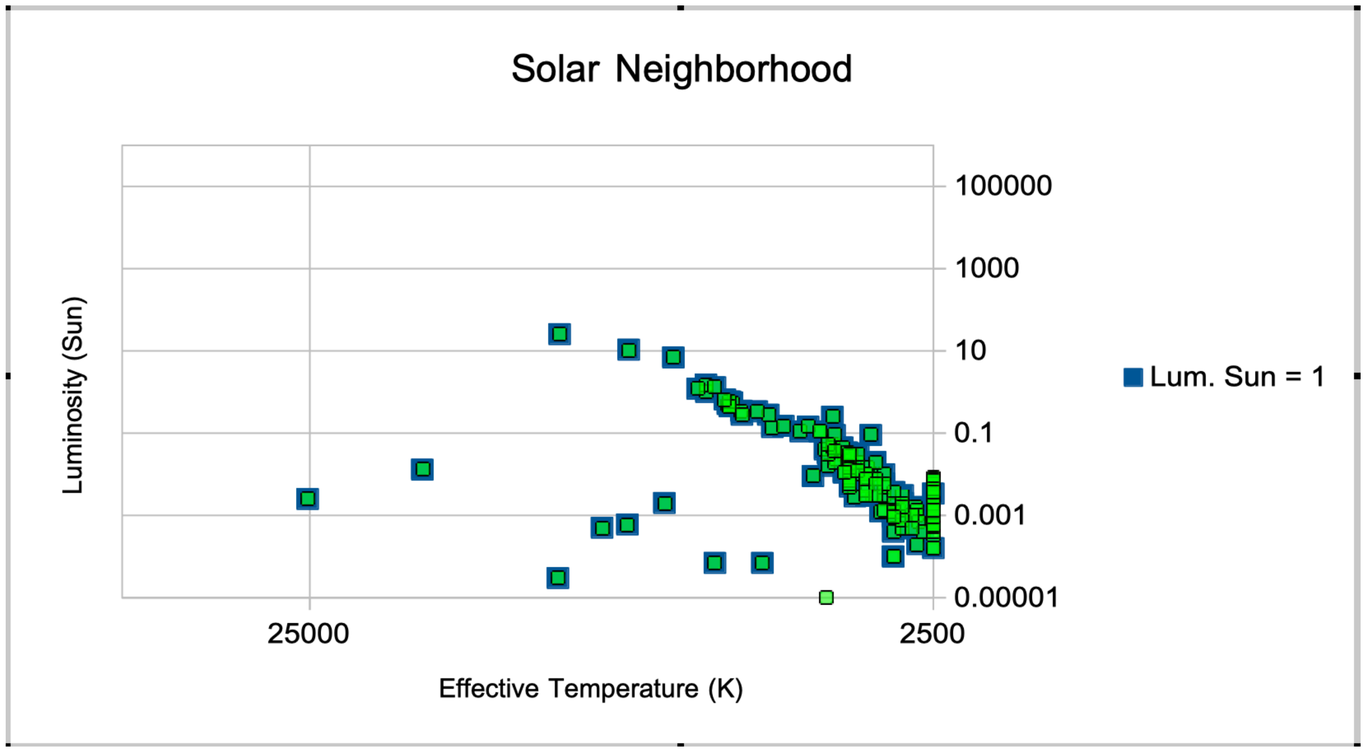
https://lavinia.as.arizona.edu/~dmccarthy/GSUSA/activities/8g%20Nearest%20and%20Brightest%20Act%20150.pdf

You see large tables containing lists of stars within 26 light years of the Earth and the brightest stars as seen in the night sky. The tables contain many quantities; the relevant ones are the effective temperature T_{eff} and stellar luminosity, Luminosity. The T_{eff} are in Kelvin (K) and luminosities in multiples of the luminosity of the Sun.

I have extracted these quantities and placed them comma separated files (.csv) and text files (.txt) at the low site:

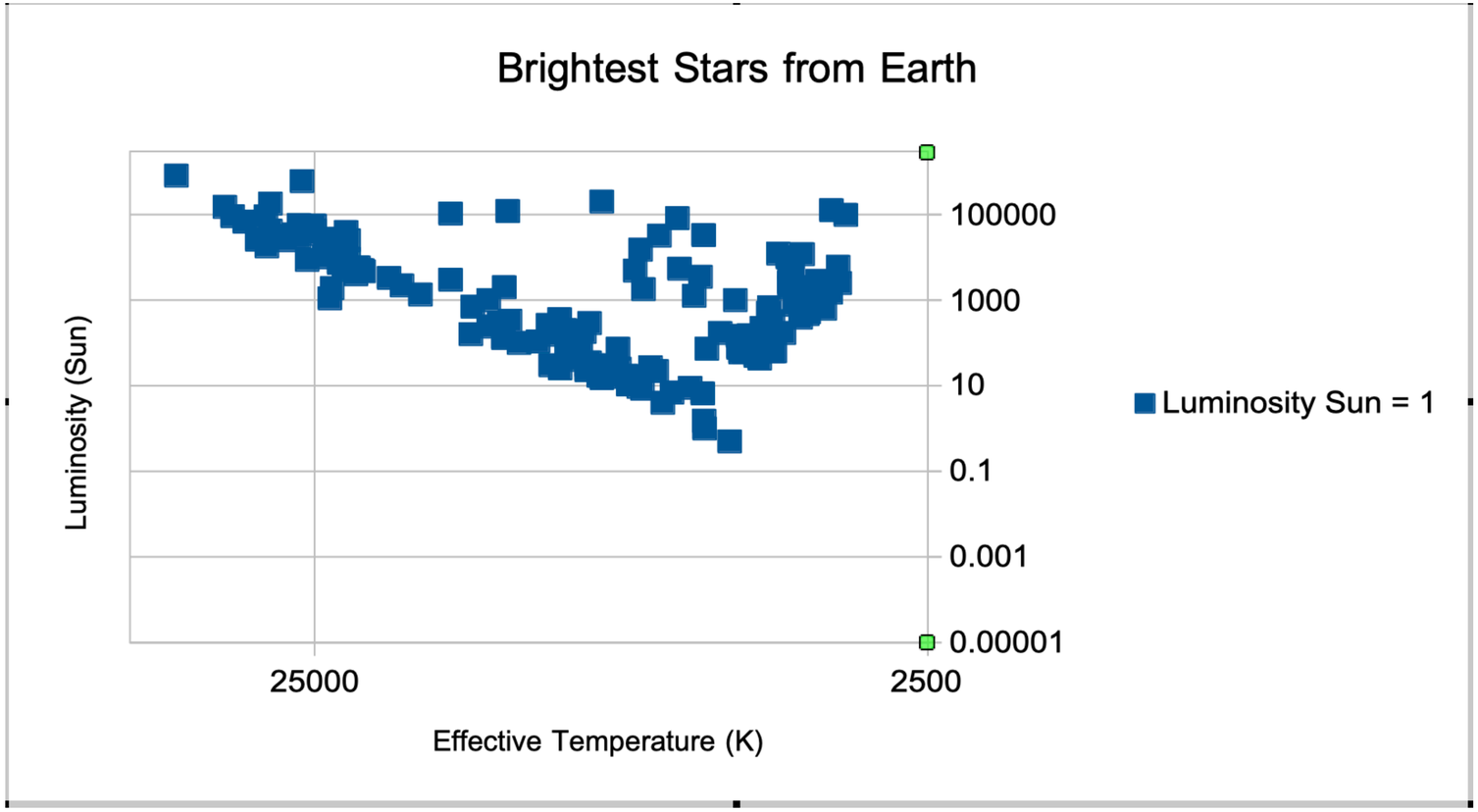
https://pages.uoregon.edu/imamura/122/homeworks/hertzsprung_russell.html

1. For the first Hertzsprung-Russell diagram, use the ***Solar Neighborhood stars***, the set of stars closest to the Sun to ***make an HR diagram***. Specifically, for the plot, use the stars within 26 light years of the Sun. Remember that the temperature is largest on the left decreasing rightward. The HR diagram for the ***Solar Neighborhood*** will look like



Circle examples of Main Sequence stars, Giant stars, Supergiant stars, and white dwarfs stars if found on your HR diagram.

2. For the next Hertzsprung-Russell diagram, use the ***Brightest stars as seen from the Earth***, the set of stars that appear brightest in the sky and ***make an HR diagram***. The HR diagram for the ***Brightest stars*** looks like



Circle examples of Main Sequence stars, Supergiant stars, Giant stars, and white dwarfs stars if found on your HR diagram.

3. *How do the Hertzsprung-Russell diagrams made for Parts (1) and (2) differ in appearance or do they appear nearly identical? To compare them easily, simply plot both sets of stars on one plot. What kinds of stars dominate each HR diagram? Look at how hot are the stars in each HR diagram, how luminous are the stars in each diagram, whether the HR diagrams are dominated by giant stars or main sequence stars, how the masses of the stars compare in the two HR diagrams.*

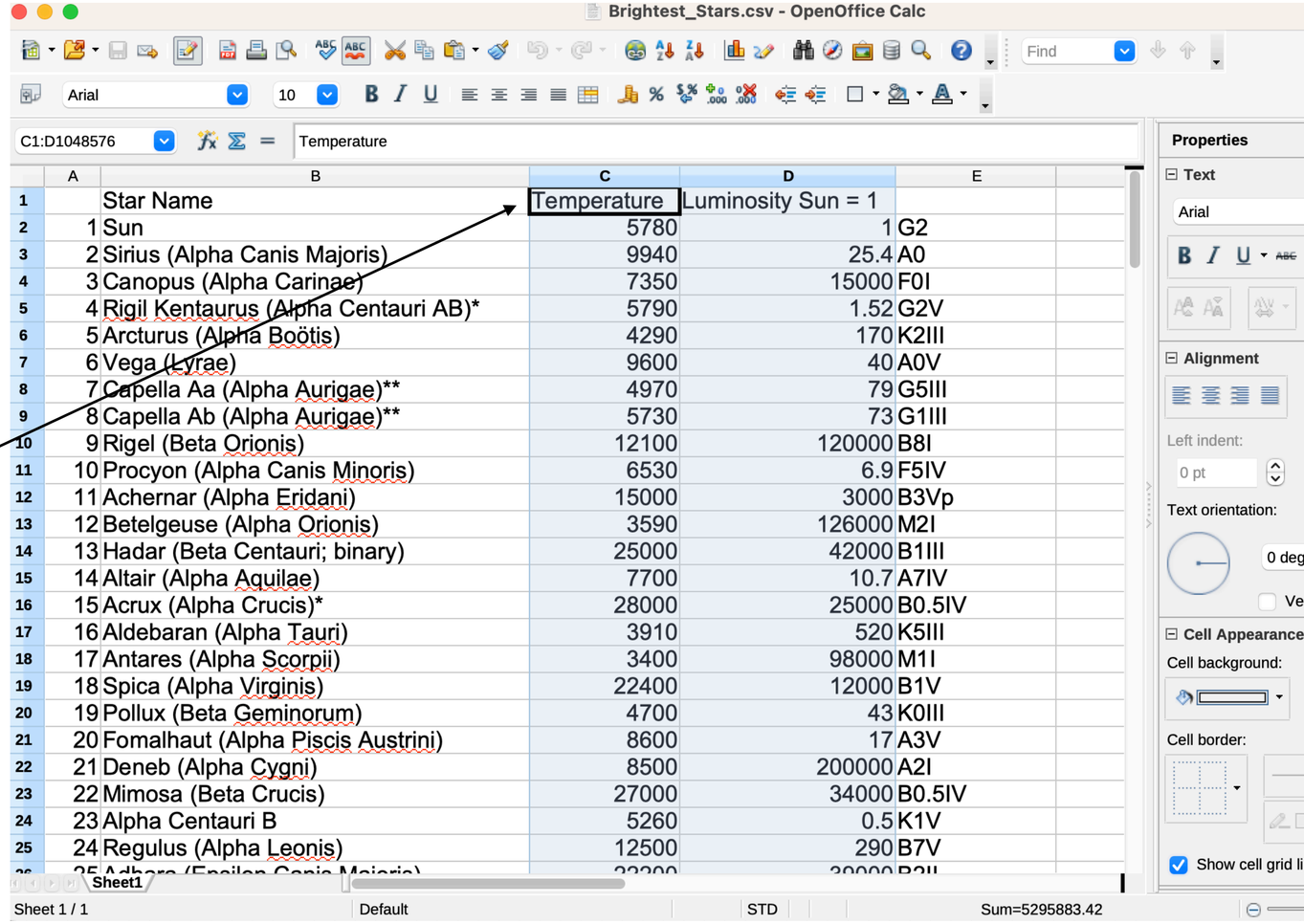
4. Based upon your HR diagrams, what can you conclude about what are the most common types of stars in the Milky Way galaxy? Are they low mass or high mass stars?

5. Based upon your HR diagrams, what might you conclude about the kinds of stars an observer in another galaxy, such as Andromeda, would find dominated the starlight from the Milky Way galaxy if they took a short exposure snapshot of the Milky Way?

I used ***OpenOffice*** a freeware software package (with the functionality of Microsoft's Office Suite of tools) to create the HR diagrams. I did not use Apple's Numbers in this case because it does not have a built-in way to *flip* axes. In the following pages, I describe how I made the plots. *You may choose to follow my template, or feel free to use any software of your liking or to make plots by hand.*

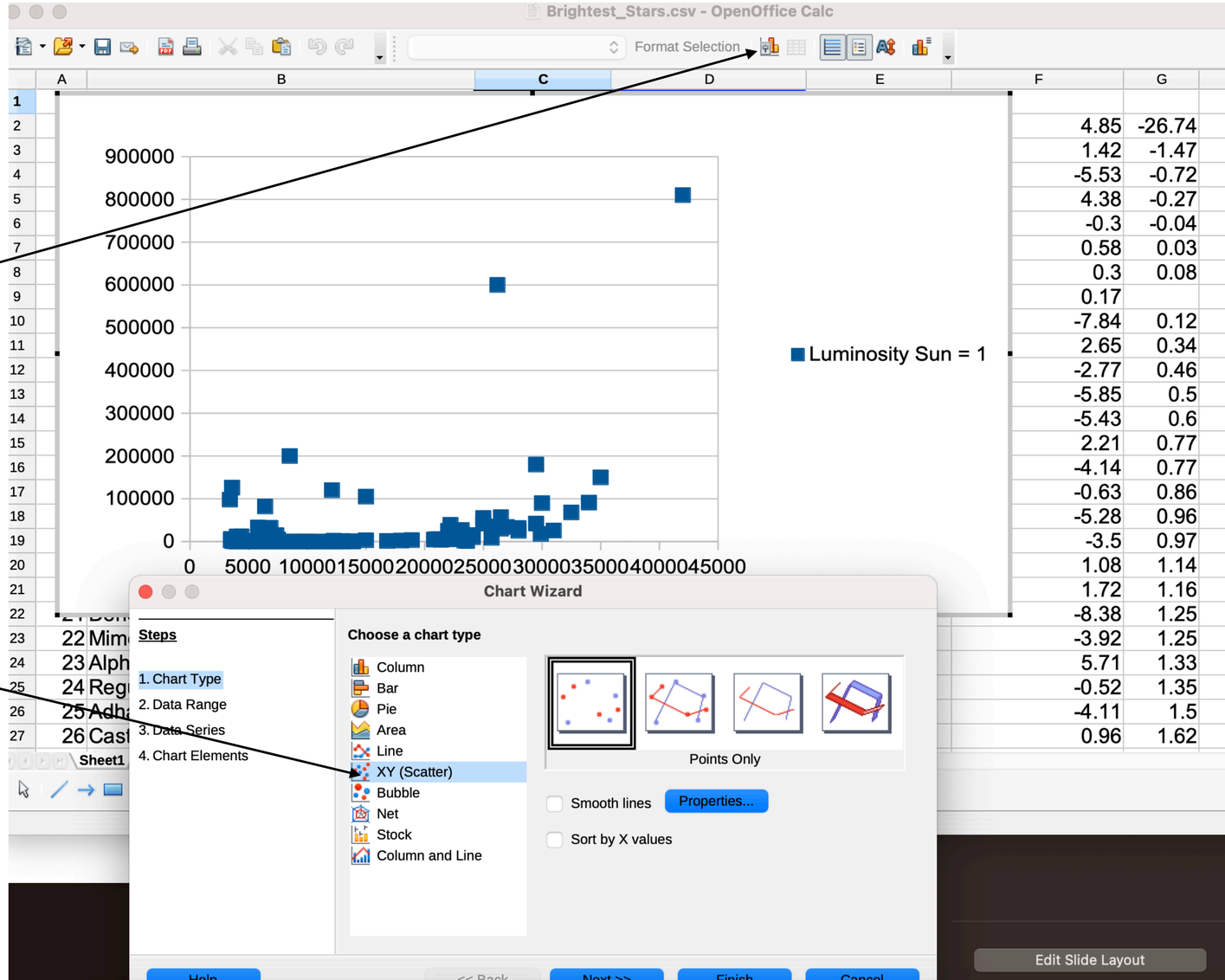
I used ***OpenOffice*** to create the HR diagrams. I did not use Apple's Numbers because it does not have a built-in way to *flip* axes.

The first step in making a plot is to choose the columns for the x-axis and the y-axis.

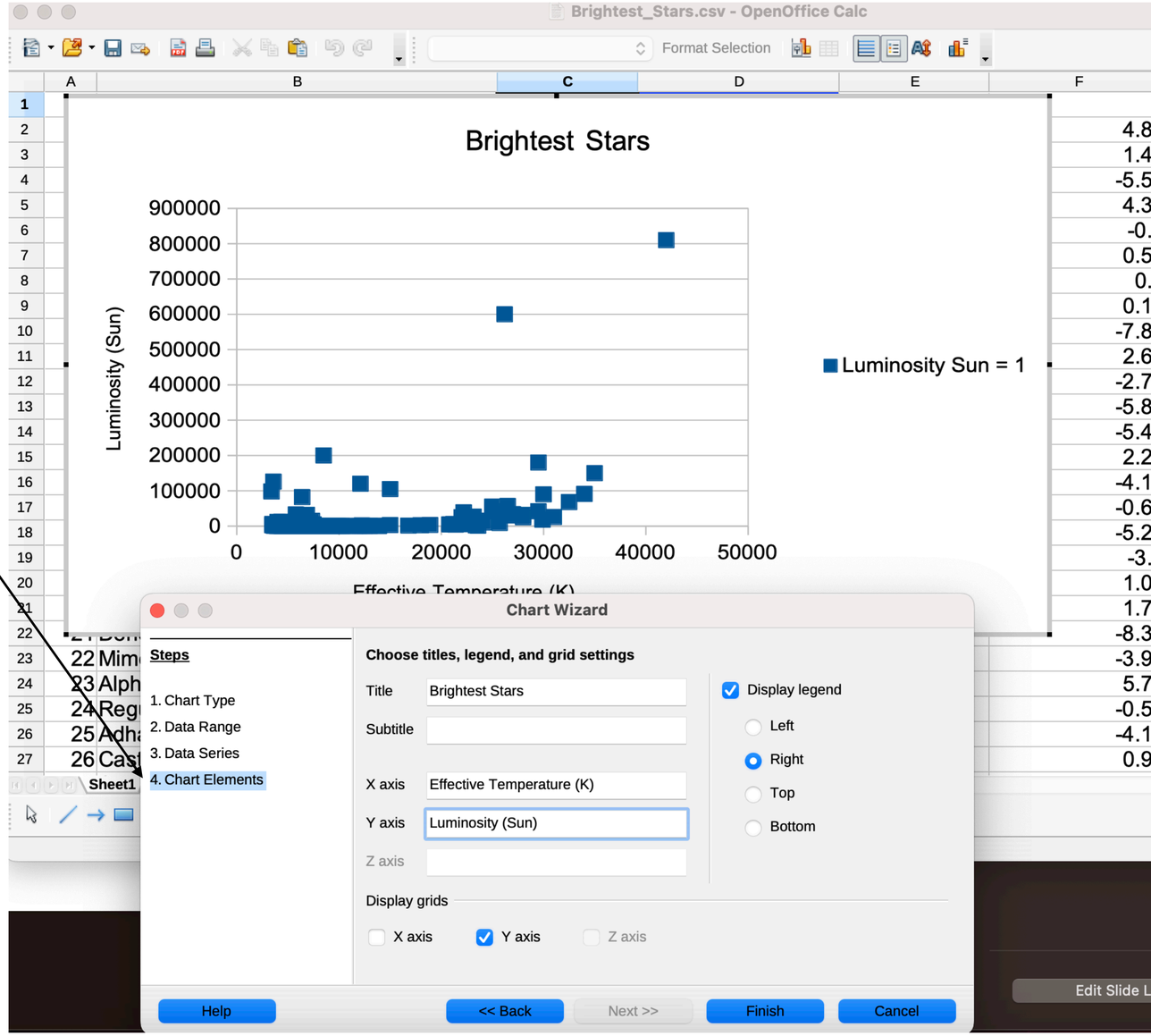


	A	B	C	D	E
1		Star Name	Temperature	Luminosity Sun = 1	
2	1	Sun	5780	1	G2
3	2	Sirius (Alpha Canis Majoris)	9940	25.4	A0
4	3	Canopus (Alpha Carinae)	7350	15000	F0I
5	4	Rigil Kentaurus (Alpha Centauri AB)*	5790	1.52	G2V
6	5	Arcturus (Alpha Boötis)	4290	170	K2III
7	6	Vega (Lyrae)	9600	40	A0V
8	7	Capella Aa (Alpha Aurigae)**	4970	79	G5III
9	8	Capella Ab (Alpha Aurigae)**	5730	73	G1III
10	9	Rigel (Beta Orionis)	12100	120000	B8I
11	10	Procyon (Alpha Canis Minoris)	6530	6.9	F5IV
12	11	Achernar (Alpha Eridani)	15000	3000	B3Vp
13	12	Betelgeuse (Alpha Orionis)	3590	126000	M2I
14	13	Hadar (Beta Centauri; binary)	25000	42000	B1III
15	14	Altair (Alpha Aquilae)	7700	10.7	A7IV
16	15	Acrux (Alpha Crucis)*	28000	25000	B0.5IV
17	16	Aldebaran (Alpha Tauri)	3910	520	K5III
18	17	Antares (Alpha Scorpii)	3400	98000	M1I
19	18	Spica (Alpha Virginis)	22400	12000	B1V
20	19	Pollux (Beta Geminorum)	4700	43	K0III
21	20	Fomalhaut (Alpha Piscis Austrini)	8600	17	A3V
22	21	Deneb (Alpha Cygni)	8500	200000	A2I
23	22	Mimosa (Beta Crucis)	27000	34000	B0.5IV
24	23	Alpha Centauri B	5260	0.5	K1V
25	24	Regulus (Alpha Leonis)	12500	290	B7V

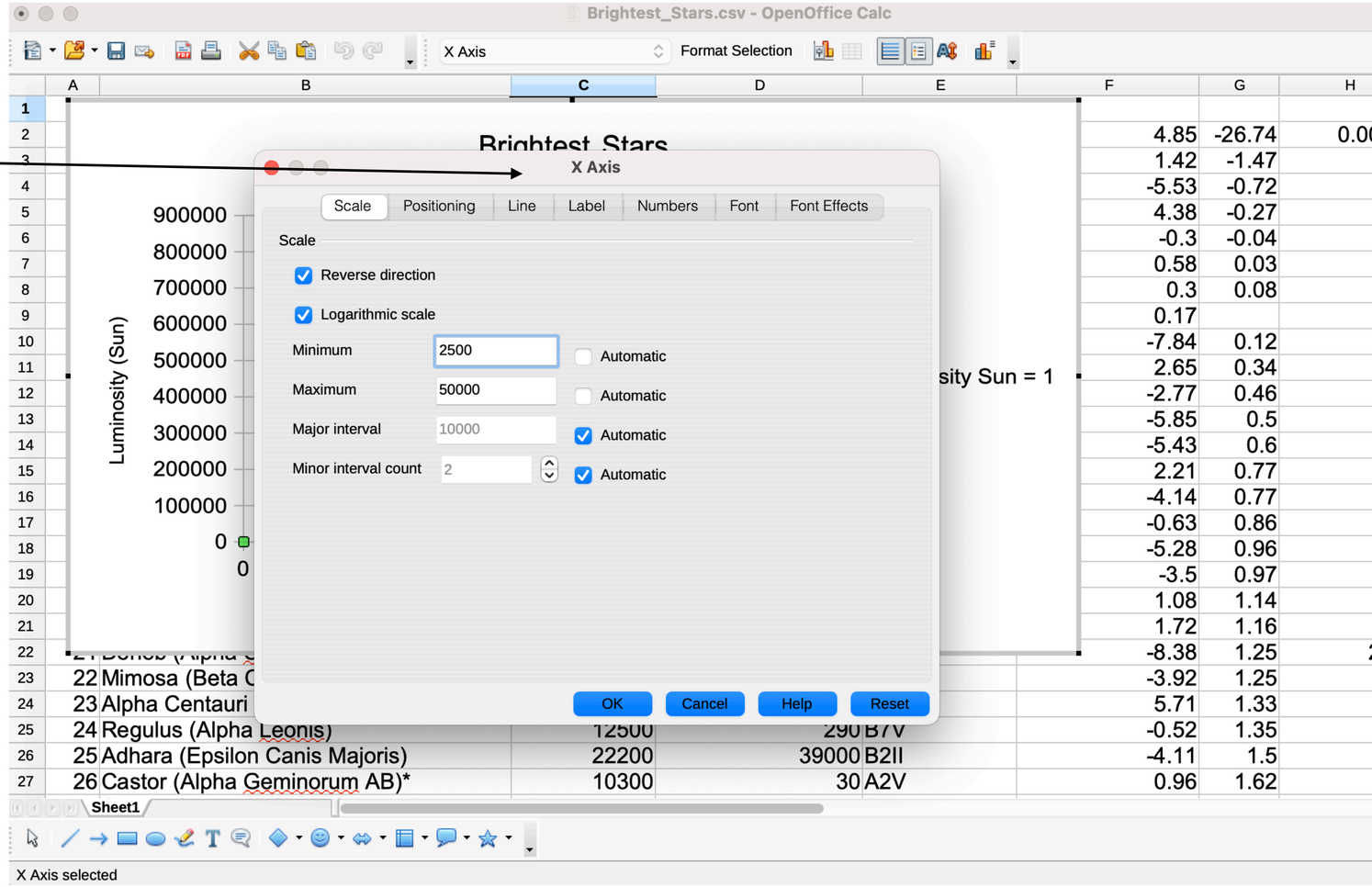
We wish to make what is referred to as a *Scatter Plot.* So, click on the *Chart Icon.* And then choose *XY (Scatter).*



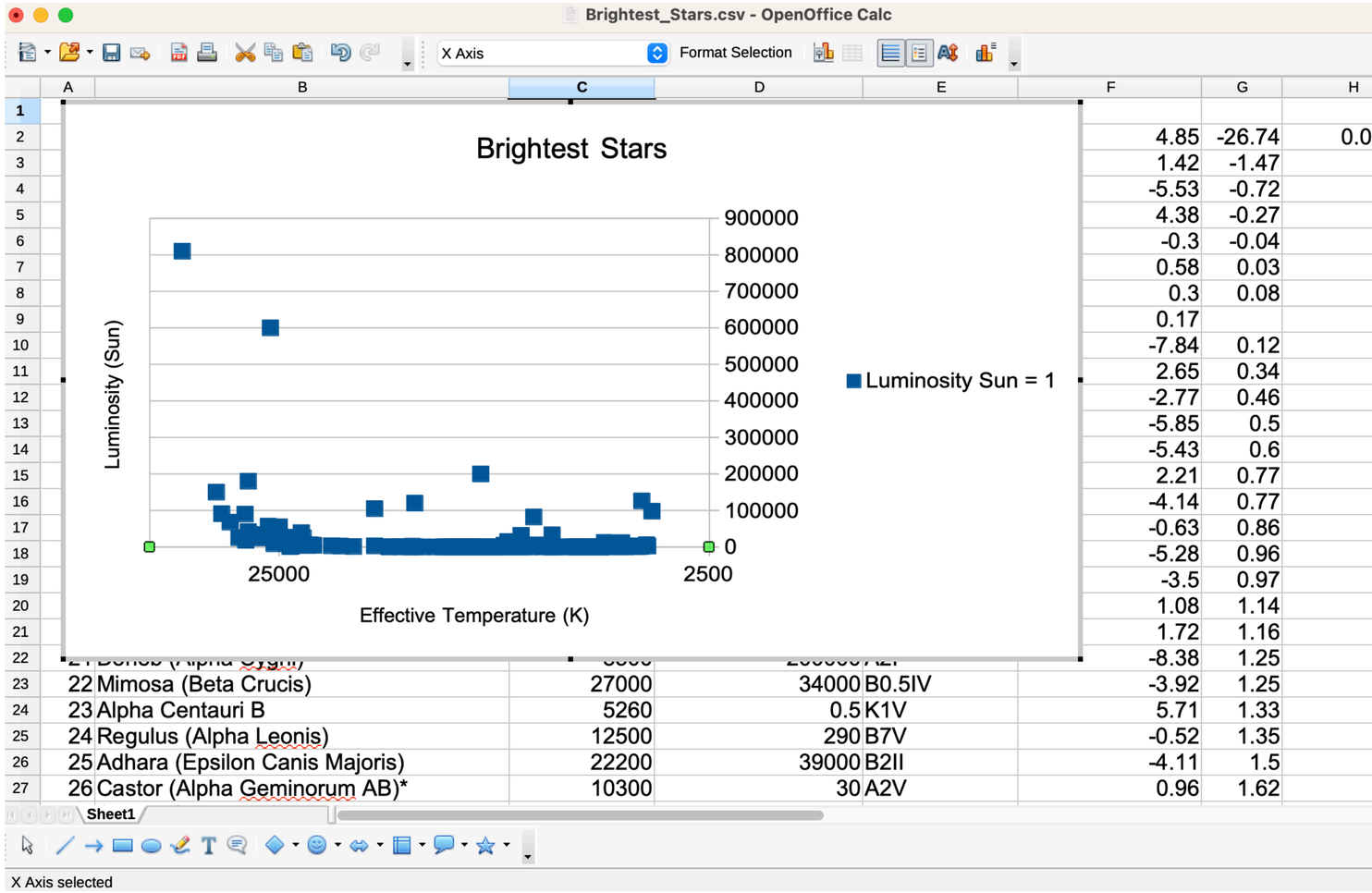
To add titles and label, click Chart Elements. Then add the title and axis labels.



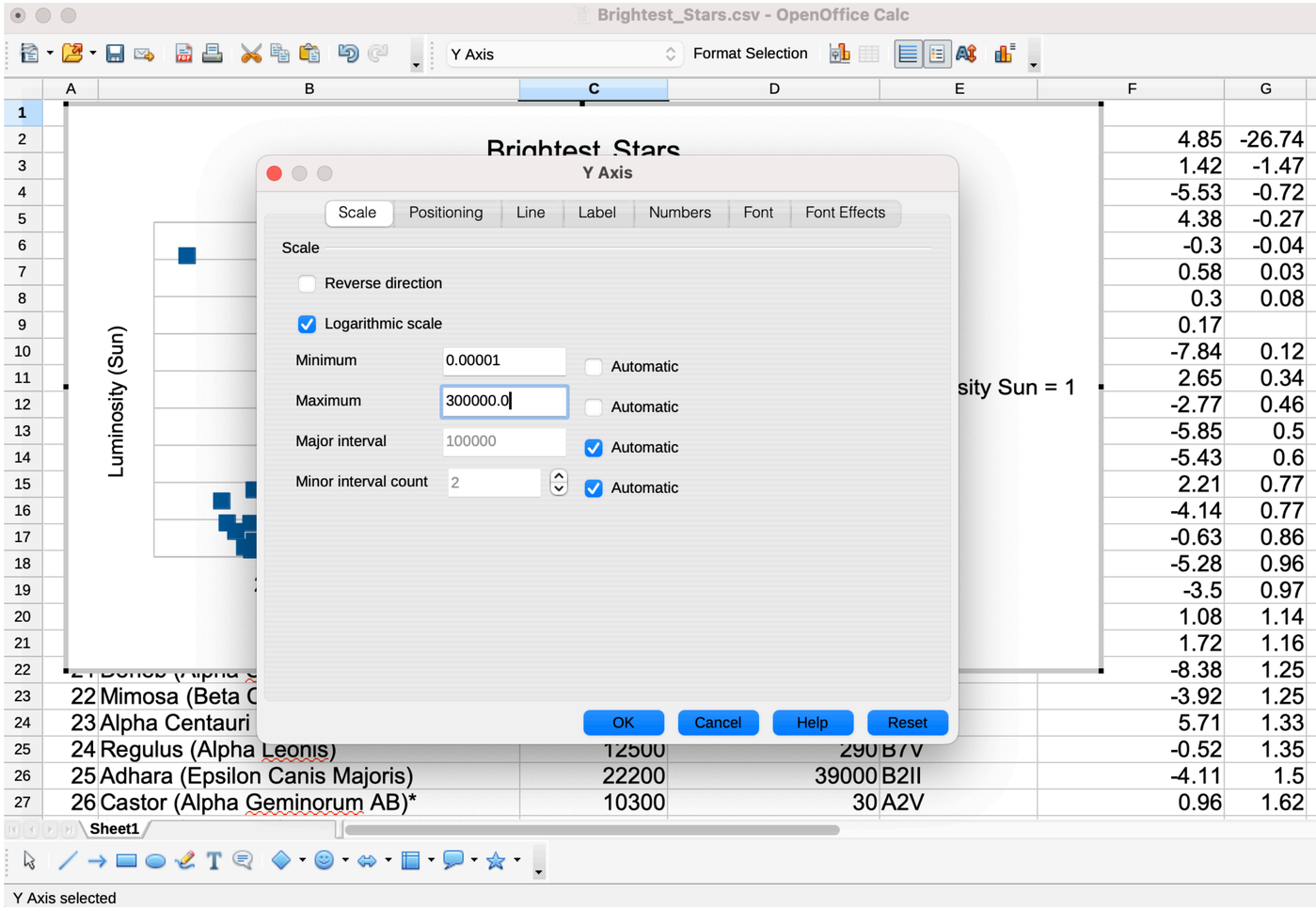
To modify the axis labels, tick marks, ranges, scales, and directions, double-click on the appropriate axis. For example on the x-axis, we bring up.



To modify the axis labels, tick marks, ranges, scales, and directions, double-click on the appropriate axis. For example on the x-axis, we change the appearance as shown to the right.

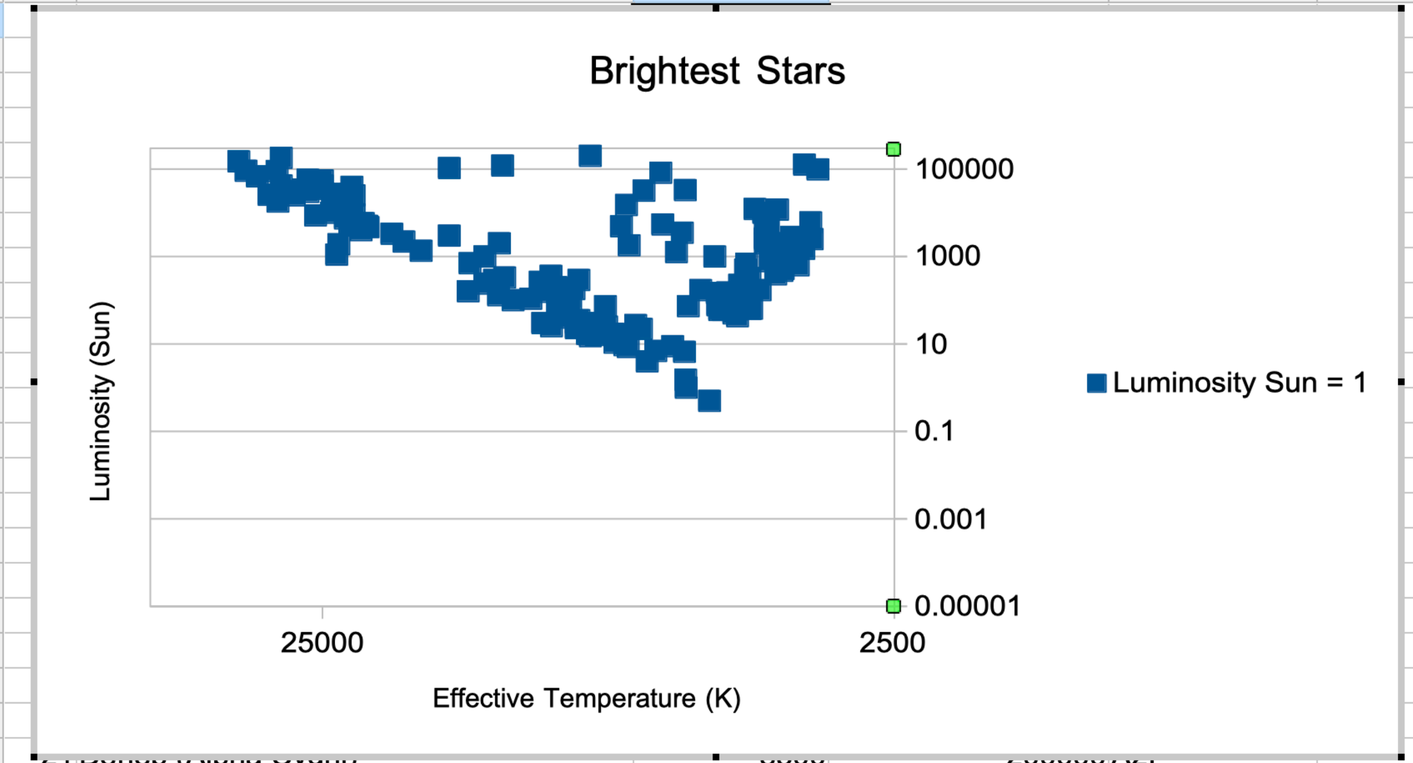


We modify the y-axis labels, tick marks, ranges, scales, and directions, similarly. Double-click on the y-axis. We change the appearance as shown to the right.



Brightest_Stars.csv - OpenOffice Calc

Y Axis | Format Selection



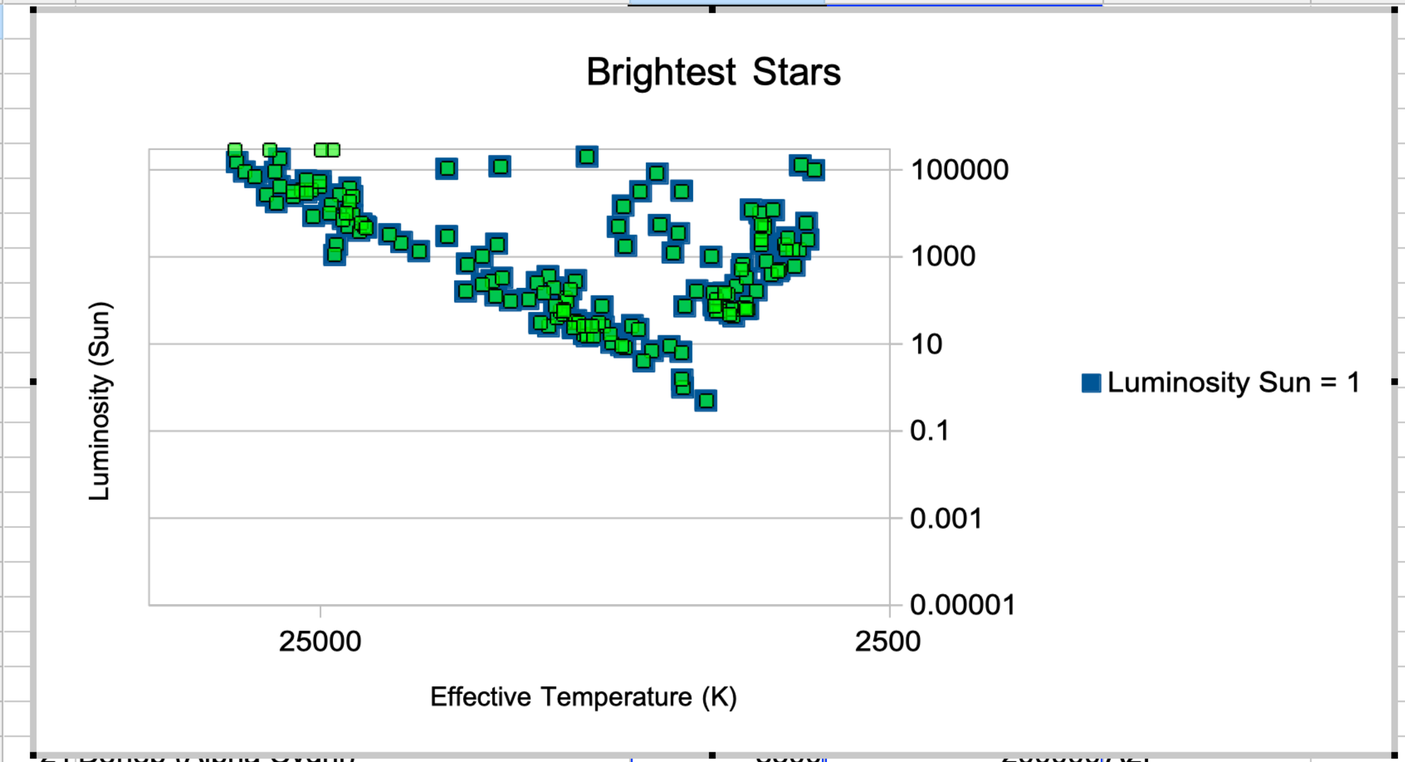
	A	B	C	D	E	F	G	H
1								
2						4.85	-26.74	0.00002
3						1.42	-1.47	8.6
4						-5.53	-0.72	310
5						4.38	-0.27	4.36
6						-0.3	-0.04	36.7
7						0.58	0.03	25
8						0.3	0.08	42
9						0.17		42
10						-7.84	0.12	860
11						2.65	0.34	11.4
12						-2.77	0.46	140
13						-5.85	0.5	640
14						-5.43	0.6	350
15						2.21	0.77	16.7
16						-4.14	0.77	320
17						-0.63	0.86	65
18						-5.28	0.96	550
19						-3.5	0.97	260
20						1.08	1.14	33.8
21						1.72	1.16	25.1
22						-8.38	1.25	2600
23	22	Mimosa (Beta Crucis)	27000	34000	B0.5IV	-3.92	1.25	280
24	23	Alpha Centauri B	5260	0.5	K1V	5.71	1.33	4.36
25	24	Regulus (Alpha Leonis)	12500	290	B7V	-0.52	1.35	79.3
26	25	Adhara (Epsilon Canis Majoris)	22200	39000	B2II	-4.11	1.5	430
27	26	Castor (Alpha Geminorum AB)*	10300	30	A2V	0.96	1.62	51

Sheet1

Y Axis selected

Brightest_Stars.csv - OpenOffice Calc

Data Series 'Luminosity Sun = 1' selected



	A	B	C	D	E	F	G	H
1								
2						4.85	-26.74	0.00002
3						1.42	-1.47	8.6
4						-5.53	-0.72	310
5						4.38	-0.27	4.36
6						-0.3	-0.04	36.7
7						0.58	0.03	25
8						0.3	0.08	42
9						0.17		42
10						-7.84	0.12	860
11						2.65	0.34	11.4
12						-2.77	0.46	140
13						-5.85	0.5	640
14						-5.43	0.6	350
15						2.21	0.77	16.7
16						-4.14	0.77	320
17						-0.63	0.86	65
18						-5.28	0.96	550
19						-3.5	0.97	260
20						1.08	1.14	33.8
21						1.72	1.16	25.1
22						-8.38	1.25	2600
23	22	Mimosa (Beta Crucis)	27000	34000	B0.5IV	-3.92	1.25	280
24	23	Alpha Centauri B	5260	0.5	K1V	5.71	1.33	4.36
25	24	Regulus (Alpha Leonis)	12500	290	B7V	-0.52	1.35	79.3
26	25	Adhara (Epsilon Canis Majoris)	22200	39000	B2II	-4.11	1.5	430
27	26	Castor (Alpha Geminorum AB)*	10300	30	A2V	0.96	1.62	51

Sheet1