AST102IN Spring, 2014 Name: ___________________

Star Scale Model Activity

Objectives: Demonstrate the variety in colors, sizes, temperatures, and lifetimes of typical stars by setting up a scale model of the solar neighborhood.

Materials: Colored balloons (red, yellow, orange, blue), rulers, tack, (small candy optional)

Part 1: Scale Model of the Solar Neighborhood

This table lists the 25 closest star systems to the sun, some of which are double or triple star systems. The "spectral types" of each star is listed in the third column according to the spectral classification scheme OBAFGKM, with O stars being the hottest, biggest and brightest and M stars being the coolest, smallest and dimmest. Also included are a few "stars" with the designations BD and WD. "BD" stars are brown dwarfs, which are failed stars just a little too big to be planets and a little too small to be true stars. "WD" stars are white dwarfs, the "dead" remnant of an ordinary star. We will discuss in later classes how this happens.

1. We'll begin by constructing a scale model of the solar neighborhood. Each group will be assigned 2-3 of the star systems below, some of which may have more than one star. It's your job to use Tables 1 and 2 to construct a scale model of the stars in your system. Choose balloons of the appropriate color according to the spectral types listed in table 1. Using those spectral types, blow the balloons up to the appropriate size for that spectral type according to table 2. List the stars that you were assigned and the color and size of their corresponding balloons.
2. After looking at the table and your models, compose 1-2 complete sentences describing how temperature, size and color are related for "ordinary" stars (ignore any WD or BD stars).
3. Your instructor will explain to you how to use the distance, RA and Dec columns to place your stars at the appropriate distance relative to the "Sun" at the center of the classroom. Once the class has constructed the model, answer the following questions:
    a. Using Table 1, create a histogram showing the distribution of spectral types in the solar neighborhood. To do this, tally up how many stars of each spectral type (O, B, A, F, G, K, M, WD and BD) are in the solar neighborhood and create a chart with spectral type along the x axis and number of stars along the y axis.
    b. What is the most common type of star in the solar neighborhood? What color/size is it?
    c. What type(s) of star is the rarest in the solar neighborhood? What color/size is it?
    d. What do your answers to (a) and (b) tell you about the relative proportions of the different spectral types that the universe creates? Is the sequence OBAFGKM related to the frequency?
    e. The nearest O star to the sun is the star Alnitak in the constellation of Orion. It's 820ly away from the sun. Is this consistent with your answer to (d). Why or why not?

f. Of these 25 nearest star systems, only 9 of the individual stars are visible to the human eye. All the rest are too faint to be seen.
    i. How are distance and apparent brightness related?
    ii. How are size and temperature related to luminosity for a star
    iii. Which stars in the table do you think are the 9 visible ones and why?
    iv. Use (i)-(iii) to explain whether you think the stars we see in the sky are representative of the true population of stars in at least one paragraph of full sentences.
g. Do you think the solar neighborhood is representative of the population of stars in the whole universe? Why or why not?
h. If the sun is an r=5in yellow balloon in this model, and it's real radius is 695,500km, then what is the scale for the sizes of the balloons? In other words, how many times smaller is the model sun than the real sun? Show your work.
i. Write down the distance scale that was used to space the stars in the solar neighborhood out and calculate the scale factor for this aspect of the scale model. In other words, how many times bigger is the real separation between these stars relative to their separations in the scale model? Show your work.
j. Your scale factors for (e) and (f) will not match. What would you have to do to make a scale model that was accurate in size AND separation for the stars? In other words, in order to make your separation scale factor the same as your size scale factor (or vice versa), how many times bigger would your model have to be?

4. As a final exercise, you will now "evolve" all of the ordinary stars in your model. As a class, we will start a stopwatch and you will pop the balloons as the stars "die". The scale for this model will be 1sec = 10 million years. Before beginning the exercise, use this scale and the real lifetimes listed in table 3 to calculate how long each type of normal star lives in our model. Fill these values in in the third column of Table 3. Give your answer in the most appropriate unit (seconds? minutes?) and show your work. Note: 1 Gyr = 1 "giga" year = 1 billion years
5. Look up the age of the universe and note where it falls in the table. How does it compare to the life cycles of various kinds of stars?
6. How many "generations" of each type of star have has there been since the universe began? Calculate the values and list them in the last column of Table 3.
7. Use the two pieces of information below to make an argument for how both small stars and large stars are necessary in order to have life in the universe.
    a. The explosions of dying stars are how all of the elements aside from Hydrogen and Helium, including most of the elements that the Earth is made of, are created and dispersed into the universe. These elements are then incorporated into stars and the planets that form around them.
    b. Life on Earth didn't arise until our planet was already 1 billion years old.

Table 1. The Solar Neighborhood

Star Name(s)	Distance (lyr)	Spectral Type	RA	Dec
Proxima Centauri Alpha Centauri A Alpha Centauri B	4	M G K	14:29	-62
Barnard's Star	4	M	17:57	+05
Luhman 16A Luhman 16B	6	BD BD	10:49	-53
Wolf 359	8	M	10:56	+07
Lalande 21185	8	M	11:03	+36
Sirius A Sirius B	9	A WD	06:45	-17
Luyten 726-8 A Luyten 726-8 B	9	M M	01:39	-18
Ross 154	10	M	18:50	-24
Ross 248	10	M	23:42	+44
Epsilon Eridani	11	K	03:33	-09
Lacaille 9352	11	M	23:06	-36
Ross 128	11	M	11:48	+01
WISE 1506+7027	11	BD	15:07	+70
EZ Aquarii A EZ Aquarii B EZ Aquarii C	11	M M M	22:38	-15
Procyon A Procyon B	11	F WD	07:39	+05
61 Cygni A 61 Cygni B	11	K K	21:07	+39
Gliese 725 A Gliese 725 B	12	M M	18:42	+60
Groombridge 34 A Groombridge 34 B	12	M M	00:18	+44
Epsilon Indi A Epsilon Indi Ba Epsilon Indi Bb	12	K BD BD	22:03	-57
DX Cancri	12	M	08:29	+27
Tau Ceti	12	G	01:44	-16
GJ 1061	12	M	03:36	-44
WISE 0350-5658	12	BD	03:50	-57
YZ Ceti	12	M	01:12	-17
Luyten's Star	12	M	07:27	+05

Table 2. Balloon Specs

Spectral Type	Color	True Radius (in R_{Sun})	Model Radius (in inches)
A	blue	2	10
F	green	1.5	7.5
G	yellow	1	5
K	orange	0.75	4
M	red	0.5	2.5
BD	brown	0.1	0.5
WD	blue	0.01	0.05

Table 3: Stellar Lifetimes

Spectral Type	Lifetime (in Gyr)	Time in Model	Number of Generations since Universe began
A	0.2		
F	3		
G	10		
K	45		
M	200+		