

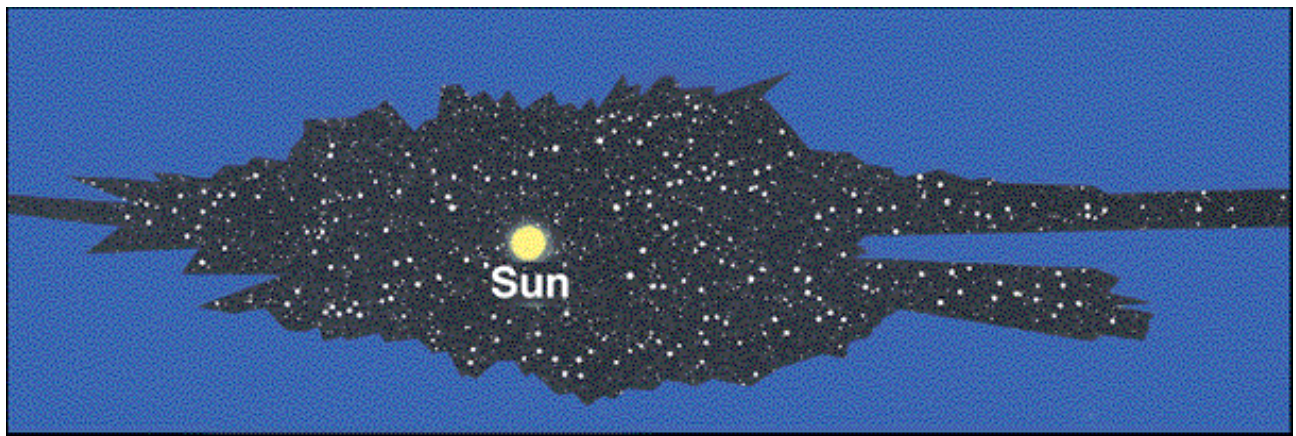
Distance to the Center of Milky Way Galaxy

Objective

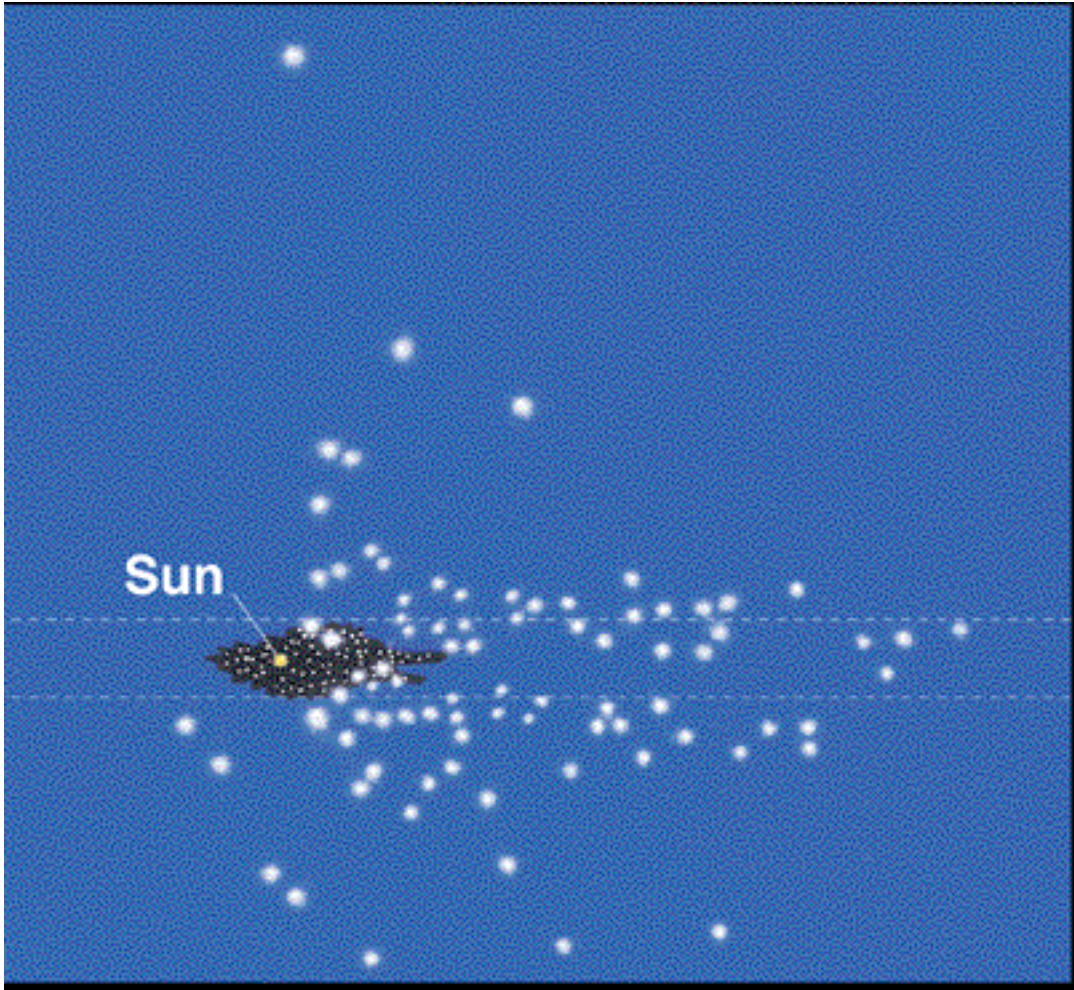
To approximate the distance to the center of the Milky Way based upon observations of globular clusters, determine whether or not the Sun is at the center of the distribution of globular clusters, state the constellation in which the center lies, and determine the best time of year to view it.

Introduction

In the not-to-distant past, astronomers thought that the Sun was at the center of our galaxy, the Milky Way. Observations and determinations of distances were hampered by the lack of knowledge of interstellar dust, dust which is so prevalent that it blocks out visual starlight of many stars (including the exact center of our galaxy) and dims the light of many others. Here is what Herschel crafted of our Milky Way by counting stars in all directions. This was in the late 1700's.



It was not until the distances to globular clusters were determined by using a type of variable stars called RR Lyrae stars, around 1920, that a more accurate picture of the size and shape of our galaxy was determined. By determining the distribution of the globular clusters, Harlow Shapley was able to determine the diameter of the Galaxy (from the diameter of the distribution) and the distance to the galactic center (from the distance to the center of the distribution). Here is how Shapley's distribution of the globular clusters compared to the "old" version of the Milky Way:



In this exercise, we revisit Harlow Shapley's method.

Procedure

Table 1 gives the distance data for about 60 globular clusters. The clusters are listed by NGC (New General Catalog) number and other names. The galactic longitude (the longitude in a coordinate system using the plane of the Galaxy as the base plane) and projected distance from the Sun are given for each cluster. Once this distribution is plotted, you should be able to determine the distance and direction to the galactic center.

Note that the distances given are the projected distances, not the actual distances. We have projected 3-D space onto a 2-D sheet of paper. The actual distances are greater than those given here, but the effect of adjusting the data will average out. Because so many clusters are being used, your answer will not be significantly affected.

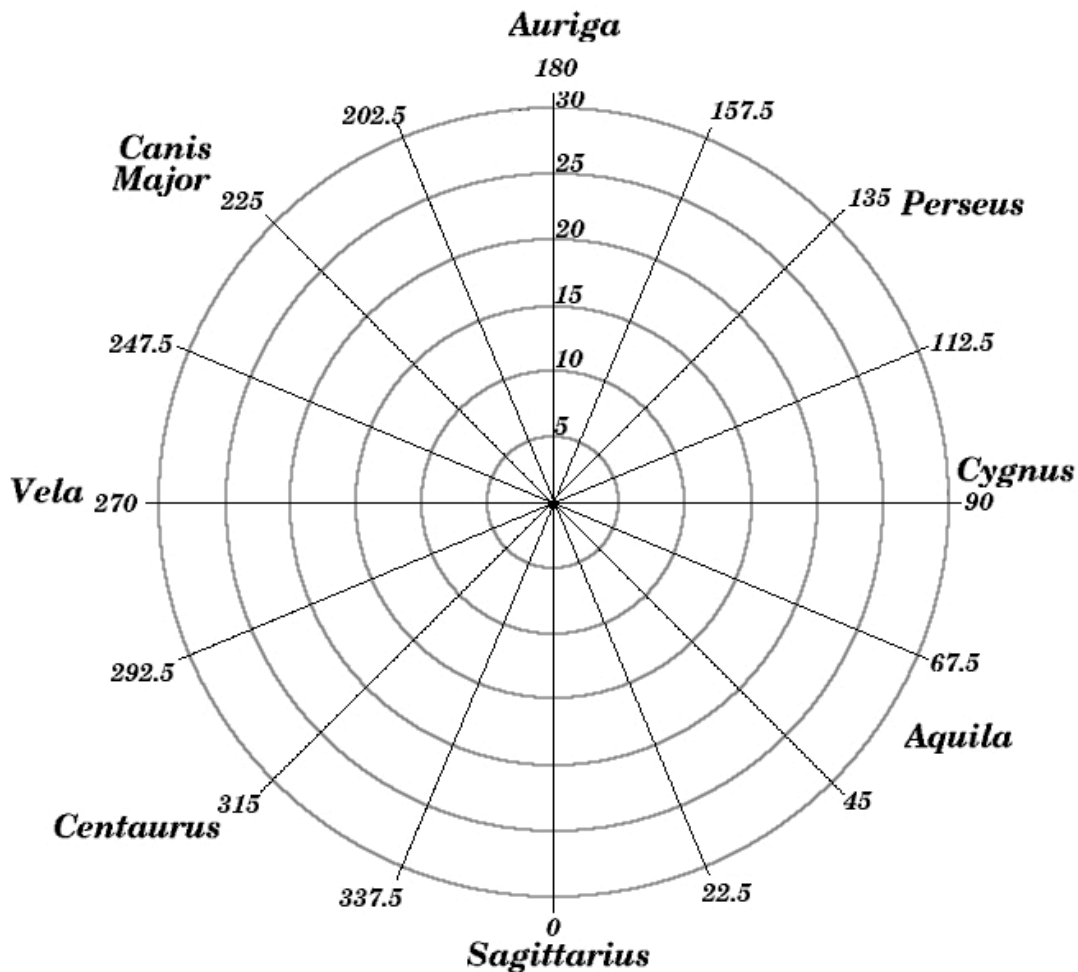


Table 1: Globular Cluster Data

NGC #	Gal. Long.	Projected Distance (kpc)	NGC #	Gal. Long.	Projected Distance (kpc)	NGC #	Gal. Long.	Projected Distance (kpc)	NGC #	Gal. Long.	Projected Distance (kpc)
104	306	3.5	6273	357	7	288	147	0.3	6284	358	16.1
362	302	6.6	6287	0	16.6	1904	228	14.4	6293	357	9.7
2808	283	8.9	6333	5	12.6	Pal 4	202	30.9	6341	68	6.5
4147	251	4.2	6356	7	18.8	4590	299	11.2	6366	18	16.7
5024	333	3.4	6397	339	2.8	5053	335	3.1	6402	21	14.1
5139	309	5	6535	27	15.3	5272	42	2.2	6656	9	3
5634	342	17.6	6712	27	5.7	5694	331	27.4	6717	13	14.4
Pal 5	1	24.8	6723	0	7	5897	343	12.6	6752	337	4.8
5904	4	5.5	6760	36	8.4	6093	353	11.9	6779	62	10.4
6121	351	4.1	Pal 10	53	8.3	6541	349	3.9	6809	9	5.5
O 1276	22	25	Pal 11	32	27.2	6626	7	4.8	6838	56	2.6
6638	8	15.1	6864	20	31.5	6144	352	16.3	6934	52	17.3
6171	3	15.7	6981	35	17.7	6205	59	4.8	7078	65	9.4
6218	15	6.7	7089	54	9.9	6229	73	18.9	7099	27	9.1
6235	359	18.9	Pal 12	31	25.4	6254	15	5.7	7492	53	15.8
6266	353	11.6									

This special polar graph sheet is to be used for the distance to the center of the Galaxy activity. The Sun (Earth) is at the very center. Each concentric circle represents 10 kpc (1 kiloparsec = 1,000 parsecs). The coordinates are galactic coordinates, with 0 degrees longitude meaning towards the "center of the Galaxy."

The named constellations are those located in the general direction of the galactic longitude shown. For example, if a globular cluster were seen at 90 degrees galactic longitude, its projected direction lies in the constellation Cygnus (although, in reality, located **well** beyond the stars that make up that constellation).



EXERCISE: ANSWER ALL QUESTIONS IN COMPLETE SENTENCES ON ANOTHER SHEET OF PAPER.

Examine the plot that follows of the data from Table 1. The Sun, and thus the Earth, is at the very center of this polar graph:

Estimate the center of the distribution of globular clusters. The best way to do this is to use a small circle (quarter, thimble, small jar lid?) and try to include as many globular clusters as possible. Mark the center on the graph. (Note: the rings you see are marking the distance from the Sun, not the center of the Galaxy.)

01. (1 pt) Determine the distance from the Sun to the center of the distribution: Distance = ___ kpc. Estimate the radius of the Milky Way based upon the distribution of the globular clusters:

Radius = _____ kpc

02. (1 pt) Determine the direction to the center of the distribution. This is considered to be the direction to the center of the Galaxy: Longitude to center of the distribution = _____ degrees

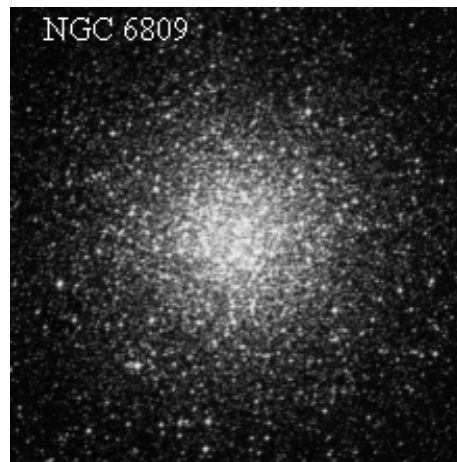
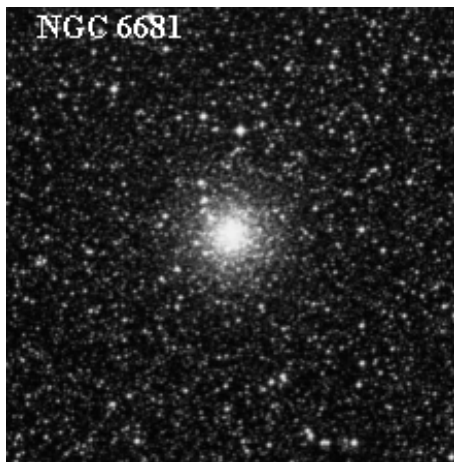
03. (1 pt) State explicitly how we know the Sun is not at the center of the Milky Way Galaxy.

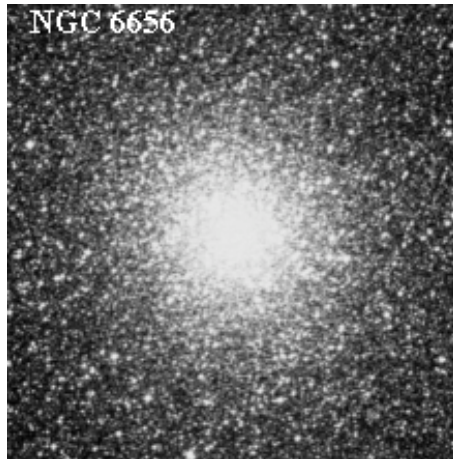
04. (1 pt) In which constellation does the center of the Galaxy lie? Constellation is:

05. (1 pt) At what month is this constellation most conspicuous (say, on the meridian at midnight) and thus give us the most advantageous view of the center of the Galaxy? (Hint: check your planisphere, or star maps in the back of the book, or planetarium program.) Month

06. (1 pt) Why do you think the Milky Way Galaxy is more prevalent in the summer than in the winter (you live in the northern hemisphere and you are to *totally ignore* weather conditions)?

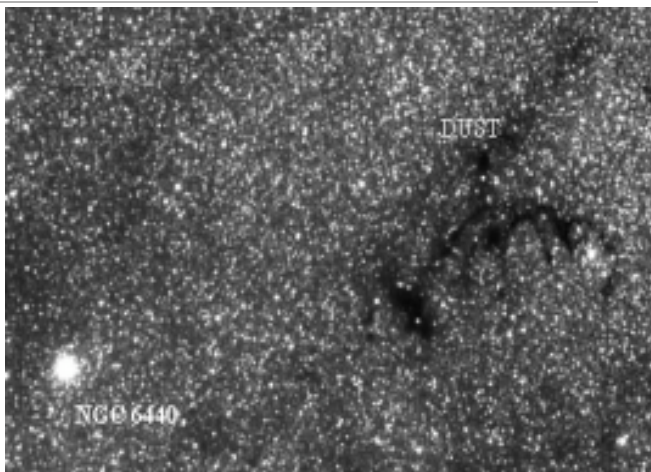
07. (2 pts) Take a look at the set of images of globular clusters that follows. Write a brief paragraph giving your interpretation of what you see. Note any obvious similarities and differences in these images. Are we able to resolve (meaning, see separate stars) many stars in any of the images? Why or why not? State one hypothesis as to why these clusters look different from each other.



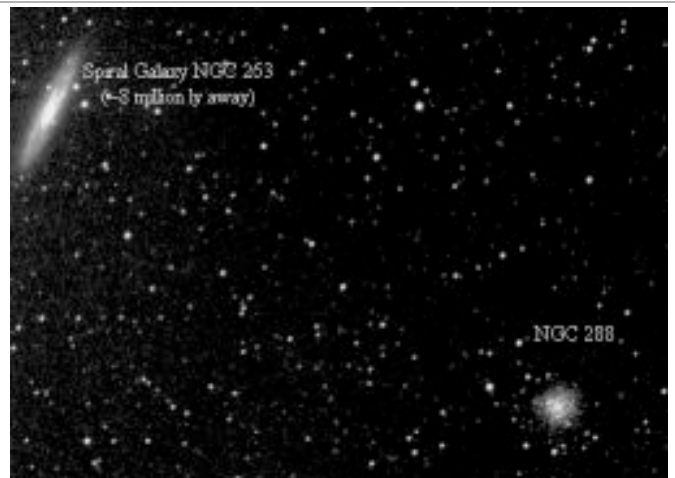


08. (2 pts) These images were all taken on the same telescope under similar observing conditions. If we assume that these globular clusters are all the same *physical* size, why would one look so big while another looks very small in these images? Check your answer with the listing of all of the globular clusters that is linked to this activity. Comment briefly.

09. (2 pts) Take a look at the images of NGC 6440 and NGC 7089 . Which one are we viewing through the plane of the Milky Way? Which one would be easier to observe in detail and why? [See links at top of activity web page for larger images.



NGC 6440 Constellation: Sagittarius
Galactic Longitude: 8 degrees
Distance from the Sun: ~8,000 pc (26,000 ly)



NGC 288 Constellation: Sculpture
Galactic Longitude: 152 degrees
Distance from Sun: ~8,000 pc (26,000 ly)

10. (3 pts) In your own words, summarize the method that was used to determine the approximate size of the Milky Way and our (the solar system's) location in it. Use good sentence and paragraph form.