

Mapping the Cosmos

Step 1 – The Solar System

1. Draw on the board a scale model of the Solar system, using circles around the Sun for planetary orbits. Use a scale of 5 cm = 1 AU. For the orbital radii of the planets, use:

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Actual distance (AU)	0.39	0.72	1	1.5	5.2	9.5	19	30
Scale distance (cm)								

You do not have to draw the physical sizes of the planets to scale, as they would be too small to see.

2. The very nearby star Sirius is about 2.6 parsecs (500,000 AU) away. How far is this on your scale model of the solar system? Express in kilometers.

Step 2 – Our Corner of the Galaxy

3. Zoom out by a factor of 200 million (!) to draw a scale model of the Galaxy (as seen face-on from above) using a scale of 5 cm = 1 kpc (1 pc = 0.05 mm). Start with the Galactic center (place it at the very top of the board). Place the Sun directly below the center at a distance of 12000 pc (60 cm). Finally, draw an arc of 20000 pc (1 meter) radius to represent the "edge" of the Galactic disk. (See diagram at right, but keep in mind it's not to scale – you'll have to use the board again!)

4. Place the following stars onto the diagram. "Galactic longitude" indicates the angle from the Galactic center as seen from Earth (or equivalently the Sun); see above.

	(Galactic center)	Sirius	Altair	Betelgeuse	Rigel	Deneb	Mu Sagittarii	Eta Carinae
Galactic Longitude	0	230	50	200	210	90	10	290
Actual distance (pc)	12000	2.6*	20*	130	240	800	1100	3000**
Scale distance (cm)								

* You will have some difficulty placing these ones on the diagram due to their small distance from the Sun. Try anyway!

** Eta Carinae is the most distant star that can be seen with the unaided eye. Unfortunately we can't see it from Berkeley, though.

5. How far away are the stars in the sky relative to the scale of the entire Galaxy? What does this tell us about trying to use stars to determine where the Galactic center is?

Step 3 – The Local Group

6. Copy the following figure to scale in the center of the board.

This is the galaxy, seen edge-on, for our next scale: 1 cm = 10 kpc (or, 1 kpc = 1 mm).

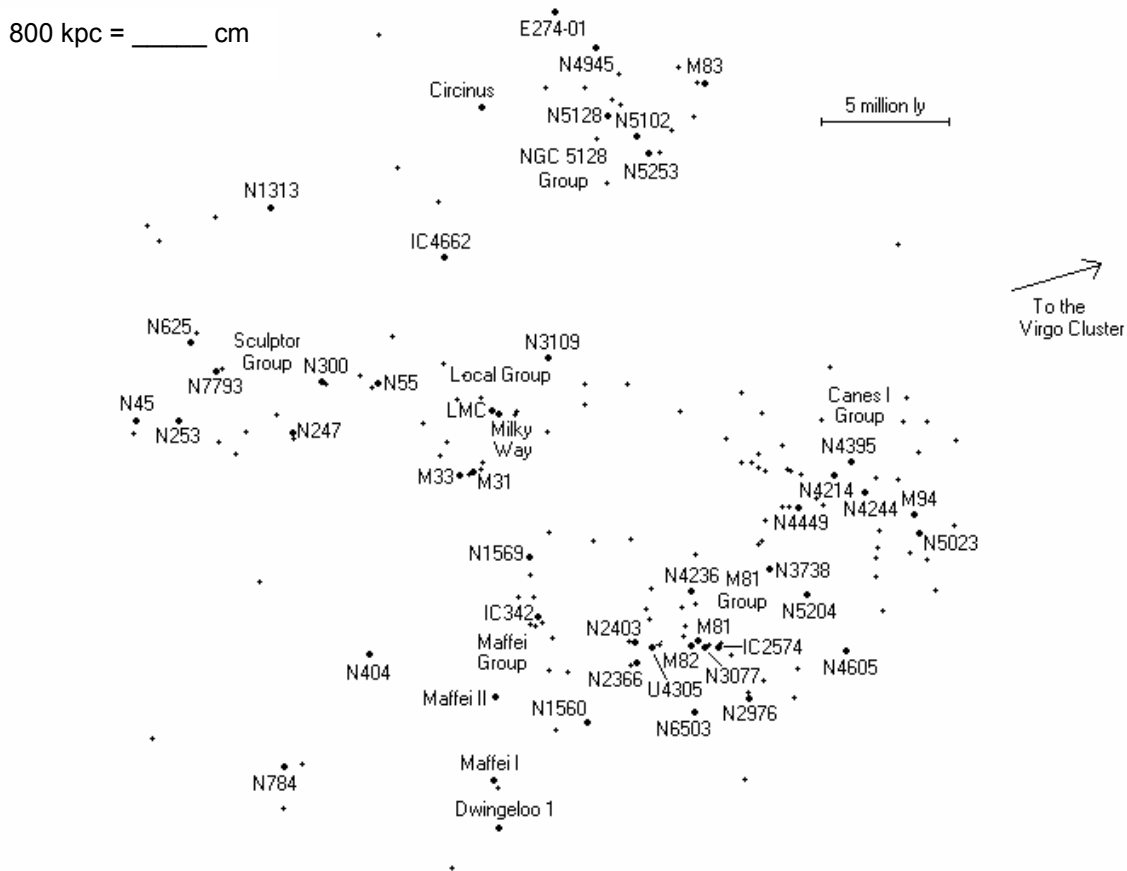
7. Draw (on the board!) the Galactic halo of dark matter, which has a radius of about 50 kpc, as a circle around the Galaxy figure drawn earlier. (Remember, the scale is 1 cm = 10 kpc, or 1 kpc = 1 mm)

8. Draw dots for the Large and Small Magellenic clouds, the Milky Way's irregular "satellite galaxies". The LMC is 55 kpc away, while the SMC is about 65 kpc away. They're in about the same direction, at an angle of about 40 degrees below the galactic plane.

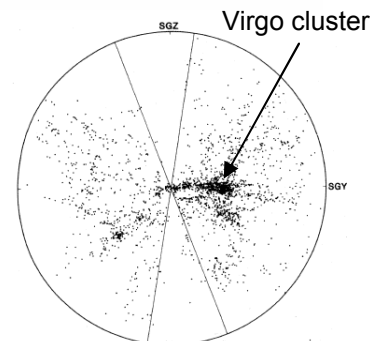
9. Draw in the Andromeda galaxy (M31), which is a distance of about 800 kpc (2 million light years) at an angle of about 20 degrees above the galactic plane. It's about the same size and shape as our own galaxy; make sure to draw it that way! The Milky Way, the Magellenic Clouds, M31 and its satellites, and one other spiral galaxy (M33, which we won't add) make up the "local group" of galaxies.

Step 4 – Galaxy Clusters and the Universe

10. The following diagram displays all the nearby galaxies to our own. Find the Milky Way and M31 below, measure their distance (on the map, in cm), and use this for your next scale:



10. The Virgo cluster of galaxies (the nearest major galaxy cluster) is about 3,000 kpc across and 15,000 kpc away. Placing this paper on the board to represent the galaxies nearest our own, draw a bunch of dots on the board at an appropriate location (see arrow) to represent the galaxies of the Virgo cluster. The Virgo cluster is at the center of the "Local Supercluster" of galaxies; we (and the galaxies above) are on the edge of this supercluster (right; but don't use this diagram for your scale – it's just for reference).



11. The observable Universe – the part that we can see (the entire universe may be infinite in extent) – is 13.8 billion light years, or about 4,000 megaparsecs (4 million kpc) in radius. On the scale of the diagram (above), how far away are the most distant objects we can possibly see?