Exercise 11: Galactic Spiral Structure

How do we know we’re in a spiral galaxy? After all, we’re looking at the Milky Way from the inside. An observation that astronomers have made of spiral galaxies that we can see from the outside (and there are plenty of these) is that the spiral arms of those galaxies contain a lot of supergiant stars (that is, non-main sequence stars with luminosities over a million solar luminosities). These spiral arms also contain a large number of O and B class main sequence stars, in two groups: OB associations (clusters of O and B stars in giant molecular clouds) and young open clusters (as you saw in exercise 10).

Sprial arms also contain large numbers of H II regions and very bright Cepheid variable stars.

The problem is that dust obscures our view of much of the Milky Way so our visual observations are limited. Fortunately, we can make enough visual observations of those types of common stars (supergiants, OB associations, young open clusters) to get an idea of how they are distributed around us.

To extend the picture, we use radioastronomy (that is, telescopes that receive radiation in the radio wave portion of the spectrum) to penetrate the dust and see even further. For this, clearly we need to know the “radio signature” of the types of stars we are interested in.

In this exercise, you will plot the distances and positions of these types of stars to determine if there is a shape to the visible part of our galaxy. Then, you will compare your results to what radio astronomy has revealed.

Break up into groups of three.

Examine the attached lists Tables 24.1, 24.2 and 24.3. Note that they list bunches of objects, each with a “l” (which is a position coordinate) and an “r” (which is a distance coordinate). Examine also the attached piece of polar graph paper. Unlike regular graph paper, it has a circular arrangement. Any point on polar graph paper can be specified by a distance from the center (“r”) along a line from the center; the line from the center is specified by a position angle (“l”) away from a 0° line (which is at the bottom of the page). The Sun (and us) is at the center of the plot.

The center of the Milky Way is thought to be 5 kpc below the bottom of the plot, along the 0° line.

1. Each person in the group should plot one table of data on their polar graph paper sheet.

Once everyone in the group finishes, align the completed polar graph paper sheets, and hold them up to the room overhead lighting. Answer the following questions:
2. Use a pencil to trace out *lightly* what you believe to be “arms” on your plots.

3. Use a dashed pencil line to draw in an alternative way in which the clumps connect with each other. Examine the gap around the 320° line especially.

4. a. On the scale of your diagram, how many centimeters across is the galaxy, if the galaxy is 30 kpc in diameter?

   b. About what percentage of the Milky Way galaxy has been mapped in this exercise?

5. Figure 24.1, illustrating the radio structure of the Milky Way, has a box in the upper half representing the area available on your polar coordinate plot. With this indication of scale, draw your optical spiral structure lines (from question 2) on this drawing (lines, not the objects themselves!).

6. Does your optical structure match the radio structure? Where do the discrepancies seem to be, if any?

7. Why can’t you use old features such as globular clusters to trace the spiral structure?

8. a. The Milky Way is very thin, almost all of its stars lying very close to its plane. Why can you observe some stars in a direction perpendicular to the plane, if it’s so flat? Hint: remember the model from exercise 9.

   b. If you see equal numbers of stars above and below the plane from Earth, what can you say about the Sun’s position in the plane?