

Galaxies and Cosmology Homework #3
Due: February 5

In this homework you'll be making a spider diagram and rotation curve for a galaxy. A spider diagram is a map of the measured velocity for a spiral galaxy, but it has to be viewed carefully since viewing angle and other aspects can effect how you measure the velocity. Generally one part of a galaxy is coming towards you and another part is going away. Also galaxies tend to be tilted to our line of sight, so to determine the actual velocity of rotation you have to take that into account.

At the course website there is a link to a program showing a galaxy. If you click on any part of the galaxy you'll get a velocity value that is detected at that point. All velocities would have to obey the relation

$$V(R,i) = V_{sys} + V(R)\sin(i)\cos(\phi)$$

where

$V(R,i)$ = the measured velocity at a particular distance, R , from the center

V_{sys} = velocity of the galaxy through space (systematic velocity)

$V(R)$ = rotation velocity (how the velocity varies with distance from the center)

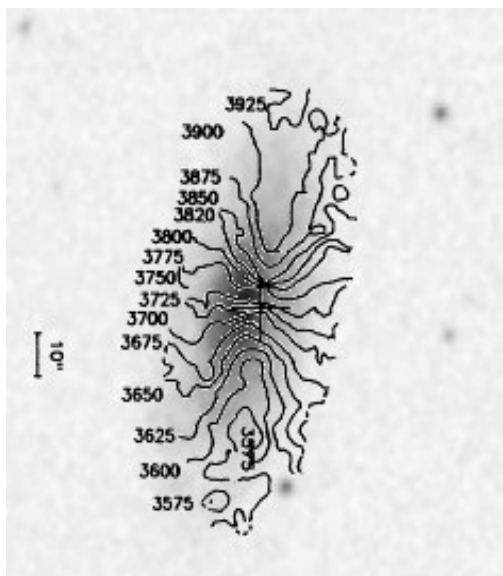
R =distance from the center

i = tilt of galaxy from the perpendicular ($i=0$ is face on, $i=90$ is edge on)

ϕ = angle from edge of galaxy (far right edge as you see it)

You're going to determine the value for V_{sys} , the rotation curve for the galaxy and the mass of the galaxy.

First you'll need to determine the velocity field for the galaxy – basically how does the velocity vary across the galaxy image. You can use the “Grid” button to show a grid that will help you record locations and velocity values over the entire galaxy. If you click off of the galaxy, there is no velocity. Systematically map out the velocity values for the galaxy.



The next step is to create a spider diagram for the galaxy. This is a contour diagram similar to that shown here that marks out boundaries of similar velocity. You will want to mark out the possible locations for the velocity values at 20 km/s intervals using your measured values. The lines get a bit crowded in the center, so don't be surprised about that.

Once you have the spider diagram constructed you can use it to determine the value for the systematic velocity (V_{sys}), basically how fast the entire galaxy is moving through space.

- Where would you find that velocity and what value did you get for the systematic velocity?

Next, use your measured values of the velocity along the main (longest) axis of the galaxy to determine the variation of the velocity with radius. This is basically figuring out the value $V(R)$ from your measured values. Since you are measuring along the long axis, the value of ϕ in the formula is 0. Also the value for i is 34 degrees. Use this information to solve the formula for $V(R)$ for different value of R .

Plot up the values of $V(R)$ versus R along the grid lines (use for R the scale values of 1-17).

b. Is the function $V(R)$ symmetric about the center of the galaxy? Is this what you'd expect?

The grid scale is 2 kpc per unit measured.

c. What is the velocity for the outermost edge of the galaxy, and what is that distance from the center?

d. Use Kepler's Third law to determine the mass of the galaxy based upon the outermost edge distance and the velocity at that location. Make sure you convert your units to the proper values. How massive is the galaxy?

Make sure you turn in your spider diagram, your plot of $V(R)$ and your answers to the questions given above.