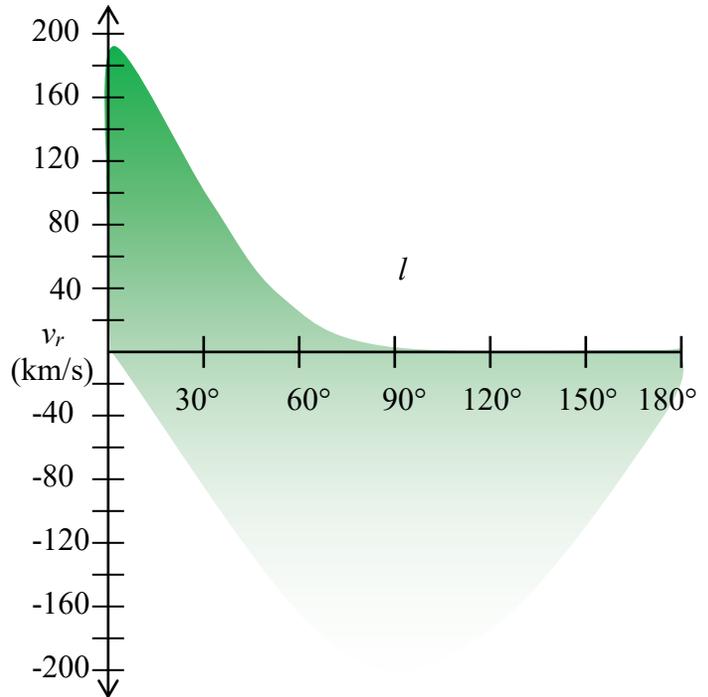


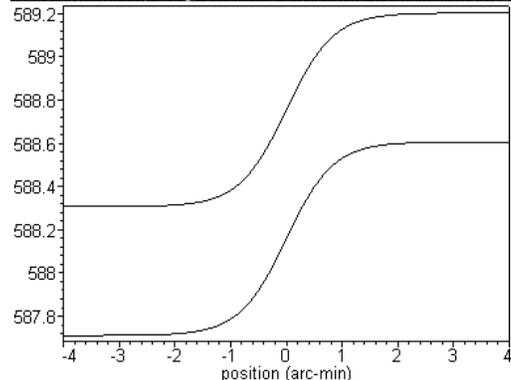
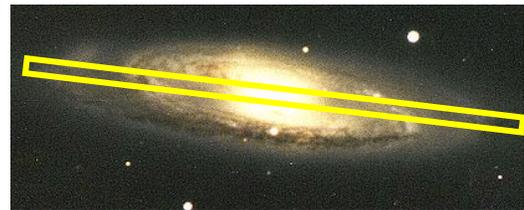
Physics 310/610 – Cosmology  
**Homework Set I**

1. An alien race is circling their galaxy in a circular orbit at  $r = 8$  kpc at a velocity of  $V = 200$  km/s. They measure the 21 cm line in the plane of their galaxy as a function of galactic longitude  $l$ . Because they are seeing through many different clouds of gas in the galactic plane, they will see different redshifts, and therefore they get a band of values, as sketched at right. Because they are lazy, they only do half of the plane.



- (a) If they want to use the tangent method to find the circular orbital velocity  $V$ , at what angle  $l$  should they examine the maximum recessional velocity  $v_r$  to determine the velocity of gas at  $r = 2$  kpc, 4 kpc, and 6 kpc from the center?
- (b) Estimate the rotational velocity at each of these angles
- (c) Plot/sketch these rotational velocities as a function of  $r$ , throwing in  $V = 200$  km/s at  $r = 8$  kpc. Does this galaxy show evidence for dark matter?

2. The galaxy at right is put through a slit spectrometer, which measures the spectrum at each point along the length of the light box shown at right. It is found that there are some spectral lines around 588 nm. This is presumably the result of the sodium-D lines, which occur in the laboratory at wavelengths of 588.9950 nm and 589.5924 nm.



- (a) Which of the observed lines is which?
- (b) At each extreme of the galaxy (left end of graph, right end of graph), what is the velocity of that side of the galaxy, and is it towards us or away from us?
- (c) Average the two velocities to estimate the velocity of the galaxy towards or away from us. What is the orbital velocity (velocity relative to the center of the galaxy) of the stars at the two extreme edges of the galaxy?
- (d) Is there evidence for dark matter in this galaxy?

**PHYSICS 610:** There are no graduate problems for this homework