Astronomy 162 – Winter Quarter 2006
Homework #3

Due in class Tuesday, February 27

Instructions

This handout is just a worksheet. Homework answers must be turned in on the bubble sheets provided. You can pick up additional bubble sheets during class.

Using a #2 pencil only (no pens), please fill out the following info:
1. Your full name, **last name** first, first name last, and remember to bubble in the letters.
2. Bubble in your answers under questions 1-5 in the fields provided on the form.
3. There is no need to bubble in any ID numbers

Please turn in your homework in class on Tuesday, February 27. **No late homework will be accepted**.

This homework assignment consists of the 5 questions below + 1 extra credit problem at the end. The non-extra-credit problems have equal weight.

1) The Sun is on a roughly circular orbit around the Galactic center with a radius of about 8000 parsecs and with an orbital speed of about 200 km/sec. Using the fact that $1pc=3.086x10^{13}$ km and 1 year lasts 365.25 days, how many **years** does it take for the the Sun to complete 1 orbit around the Galaxy? [pick the closest answer from below]? (Hint: the circumference of a circle is $2\pi r$ and speed=distance x time)

   a) 240 million years
   b) 2.4 billion years
   c) 24 million years
   d) 2.4 million years

2) You observe that a star cluster orbits in a spiral galaxy with a rotation velocity of 250 km/s at a distance of 10 kpc. What can you conclude about the mass of the galaxy? Note that the "greater/lesser than or equal part" is not related to rounding the answer on your calculator, but rather the definition of M(R). (Hint: $G=6.67x10^{-20}$ $(km^{3)}/(kg\ s^2)$, 1 $pc=3.086x10^{13}$ km and 1 $M_{Sun}=1.99x10^{30}kg$).

   a) The mass is greater than or equal to $1.45 \times 10^{14}\ M_{sun}$
   b) The mass is less than or equal to $1.45 \times 10^{14}\ M_{Sun}$
   c) The mass is greater than or equal to $1.45 \times 10^{11}\ M_{Sun}$
   d) The mass is less than or equal to $1.45 \times 10^{11}\ M_{Sun}$

3) Which of the following is NOT evidence that the stars in elliptical galaxies are generally old?

   a) Red color of elliptical galaxies
   b) Weak hydrogen absorption lines in the integrated stellar spectra
   c) High velocity dispersions
   d) H-R diagram of individual stars in elliptical galaxies

4) You observe that the total luminosity of an elliptical galaxy is 6.25×10^{10} $L_{Sun.}$ All of the light is from the stars. The stars in this galaxy are quite old, and their average mass is 0.5 M_{Sun}. If you assume that each star in the galaxy has a mass of 0.5 M_{Sun} and are on the main sequence (not correct, but close enough for this question), how many stars are in this galaxy? (Hint, use the mass-luminosity relation for stars on the main-sequence to figure out how luminous each star is.)

   a) 1×10^{12} stars
   b) 2.5×10^{11} stars
   c) 2.5×10^{9} stars
   d) 1×10^{8} stars

5) The total mass of the galaxy in the above question, measured from the motions of the stars, is 5×10^{12} M_{Sun}. There is no gas or dust, so all of the mass is in stars or dark matter. How much dark matter is necessary to explain the motions of the stars? (pick the closest answer) (Hint, calculate the total mass in the stars assuming again that they each have a mass of 0.5 M_{Sun} and subtract it from the total mass)

   a) 4.9×10^{12} M_{Sun}
   b) $1.0 \times 10^{12} M_{Sun}$
   c) $4.0 \times 10^{12} M_{Sun}$
   d) $4.5 \times 10^{12} M_{Sun}$

EXTRA CREDIT PROBLEM

Dr. Chris Mihos has an excellent applet for exploring how dark matter helps fit the rotation curves of spiral galaxies. Please go to burro.astr.cwru.edu/JavaLab/RotcurveWeb/main.html and click on the Applet (feel free to read the additional info if you'd like)

For this problem, we are going to study UGC128, which should be the galaxy whose rotation curve you see when you pull up the applet. There are three things you can change: the disk mass-to-light ratio (or how much matter is in the stars), the dark halo central density (or how much dark matter there is) and the dark halo core radius (or the shape the dark matter has).

1) First try to fit the rotation curve using only the disk (=leave the halo central density at zero). You can adjust the amount of matter in the disk by changing the mass-to-light ratio, but you cannot alter the distribution of matter, since it is fixed by our observations of the disk. You can measure how well you are doing by looking at the ChiSq statistic in the lower part of the graph. ChiSq < 2 is a good fit. You should have lots of trouble. Print out or sketch your "best fit" and explain why this means that you need dark matter.

2) Now add a dark matter component. By adjusting the halo central density and core radius, you should be able to get a ChiSq < 2. Write down your values for the central density, the core radius and the disk mass-to-light ratio. Print out or sketch your final fit to the rotation curve. Conclude that dark matter provides a good solution for fitting this galalxy's rotation curve.

p.s. Feel free to play with the other two galaxies with rotation curve data in the applet. I found that fitting them even with dark matter, was much harder. I suspect it is because the disk mass-to-light ratio was forced to be constant for the whole galaxy, even though that is usually not true in reality.