Astronomy 540 – Homework 1

Due Wednesday, September 20, 2006

1. Download the M31 surface brightness profile from the class web page (http://ircamera.as.arizona.edu/Astr_540).

a. Using interactive software of your choice (eg., IDL, spreadsheet, Mathematica,) fit these data with a two-component model using a bulge and a disk. You should turn in a plot showing your fit, the functional forms you used, and the fitting parameters. Do not be tempted to use one of the canned bulge/disk fitting programs that are relatively easy to find, as part of the value of this exercise is for you to see how tricky it can be to perform this type of fitting, and to see why there have been debates about disk central surface brightnesses, and so on. Don't worry about trying to produce the very best fit, but get close and indicate what you think is a plausible range that encompasses the best fit parameters.

b. Knowing that these data are from M31, what are the physical lengths associated with your fitting parameters?

c. Using data out to ∼5000 arc sec, what's the bulge-to-disk luminosity ratio for M31? Does this match its Hubble type?

d. If the stars in the M31 bulge have M/L = 3, over what distance would a nuclear black with mass=10^7 M_{Sun} dominate the gravitational field?

(problem 2 on next page)

2. Rotation curve for a generalized NFW halo.

a. For a spherical dark matter halo density profile given by

$$\rho(r) = \rho_0 \frac{1}{(r/r_s)^\alpha (1 + r/r_s)^{3-\alpha}} \tag{1}$$

derive the disk rotation curve in terms of rotation speed at the virial radius v_{200}, scaled radius $x \equiv r/r_s$ and concentration $c \equiv r_{200}/r_s$ (along with inner slope α). Assume that the mean density within the virial radius is 200 times the critical density. You can ignore the contributions to the rotation curve from baryonic components. Show your work.

b. Write a C program to input v_{200}, c, and α, and output the rotation curve out to the virial radius, in units of kpc vs. km/s. You can email the C program to Romeel; it should compile under gcc. If you do not know C, this is a good chance to learn! (A concise tutorial is available at http://www.physics.drexel.edu/courses/Comp_Phys/General/C_basics/c_tutorial.html).

c. Use your favorite plotting program (IDL, supermongo, etc) to plot this rotation curve for $v_{200} = 200$ km/s, $c = 10$, and $\alpha = 0, 0.5, 1$, and 1.5. The plot should use different line types for the various choices of α, along with a legend describing the line types. Turn in a hardcopy of the plot.