Astronomy 128

Assignment 6, Thursday, Feb. 28th

1. Finish off your rotation curve fits and be prepared to hand them in.

2. We will discuss the the paper that was assigned last week: "The Tully-Fisher Relation and H_o", Astrophysical Journal, 477: L1-L4, 1997.

3. Everybody read the following from Binney and Tremaine. Chapter 2, up to section 2.2 inclusive. This is review, but introduces the notation. Chapter 3, up to section 3.2 inclusive.

4. Do problems 2-1, 2-3, 3-4 and 3-6 in Binney and Tremaine.

5. Use IDL's Runge-Kutta integrator RK4 to investigate the orbits of stars in a spheroidal potential.

   (a) Consider the Logarithmic spheroidal potential given by equation 3-50 in Binney and Tremaine (page 115):

   $$\Phi_{eff} = \frac{1}{2} v_o^2 \ln \left(R^2 + \frac{z^2}{q^2} \right) + \frac{L_z^2}{2R^2}$$

   where all these variables are in arbitrary units. Show that the equations of motion (equations 3-49a of BT) can be reduced to 4 coupled first-order differential equations:

   $$\dot{y}_i \equiv \frac{dy_i}{dt} = f(t, y_i), \quad i = 1..4$$

   (b) Write an IDL function which computes the values of dy_i/dt. This function should take as input a vector $[t, y_1, y_2, y_3, y_4]$ and return a vector $[\dot{y}_1, \dot{y}_2, \dot{y}_3, \dot{y}_4]$. Use this function with the RK4 routine in IDL to compute the orbit of a particle in the potential and plot the orbits in the (R, z) plane. L_z is a free parameter here, so you can set it to some arbitrary value (like 0.2). Set $v_o = 1$ and use arbitrary units for distances and time intervals (we're more interested in the shapes of the curves, not absolute quatities). Try the following scenarios:

      i. $q = 1$ (spherically symmetric). Play with the different initial conditions. You should find that you get a rosette pattern with an inner and outer radius. How do the initial conditions affect the inner and outer radii?

      ii. $q = 0.9$ (sligthtly flattened). Try the same initial conditions you used above.

      iii. $q = 0.5$ (highly flattened). Again, try the same initial conditions.

   (c) What are the qualitative differences between the 3 degrees of "flatness"?

(d) For a few interesting cases you found in part (b), plot a "surface of section" (SOS) as outlined in BT, section 3.2. Do you think the phase points would fill in a region of the SOS or do they fall on some kind of curve? What does this imply about the possibility of another integral of motion besides the energy and z-component of the angular momentum L_z?