ASTR 400B In Class Lab 2

Feb 1st 2018

The Large Magellanic Cloud is at a distance of 50 kpc from the Galactic Center. It is observed to have a stellar disk that extends to a radius of at least 18.5 kpc. See Figure 1.

Using the mass breakdown for the Snapshot 0 MW model from assignment 3, determine the minimum mass required for the LMC so that it maintains the observed radius in the face of the MW's tidal field.

The Jacobi Radius for a satellite on a circular orbit about an extended host following an isothermal sphere halo is:

$$R_j = r\left(\frac{M_{sat}}{2M_{host}(<r)}\right)^{1/3} \tag{1}$$

1 M_{host}: MW Mass Profile

In the simulation the MW is modeled as a Hernquist sphere with the following density profile:

$$\rho(r) = \frac{Ma}{2\pi r}\frac{1}{(r+a)^3} \qquad M(r) = \frac{M_{halo}r^2}{(a+r)^2} \tag{2}$$

Create a function *HernquistM* that returns the Hernquist halo mass at a given radius. This function should take as input: the scale radius a, the halo mass M_{halo}, and the distance to the satellite, r.

1.1 Question 1

Using $a = 60$ kpc for the scale length and M_{halo} from the total dark matter halo mass in assignment 3, determine the total MW mass enclosed (Mdark + Mdisk+ Mbulge) within the 50 kpc separation of the

2 M_{sat}: Mass of the LMC

Create a function that returns the satellite mass, given the host mass and satellite separation, and observed size. Do this by rearranging the equation for the Jacobi Radius.

We are assuming that the mass of the MW within 50 kpc can be well approximated by an isothermal sphere model (which it can, if V_c = 206 km/s rather than 220 or 240). Note

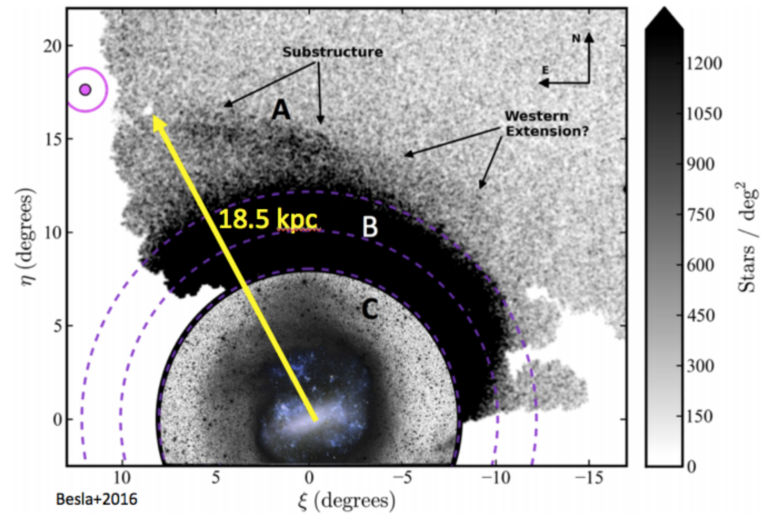

Figure 1: Deep photometric imaging reveals the faint stellar outskirts of the LMC. Outskirts: DECam data Mackey+2016. Inner: shallower imaging from robotic telescopes Besla+2016.

also that the LMC is not on a circular orbit, but it is very close to its pericentric approach, where the velocity is all in the tangential component. So this isn't a terrible approximation.

2.1 Question 2

What is the required mass of the LMC to survive against the tidal field of the MW ?

3 Consistency Check

The maximal enclosed mass of the LMC at any radius can be determined by assuming a flat rotation curve.

$$V_c^2 = \frac{GM}{r} = constant \tag{3}$$

G = 4.498768e-6 kpc^3/Gyr^2/M$_\odot$ (note that 1 kpc/Gyr $\sim$ 1 km/s). The rotation curve of the LMC is observed to be 91.7 +/- 18.8 kpc (van der Marel & Kallivayalil 2014).

3.1 Question 3

What is the maximal mass enclosed by the LMC within the observed radius? Is it consistent with the minimum mass needed to explain the observed radius of the LMC given the tidal field of the MW? If not, how can the numbers be reconciled?

Note the following :

1. the minimum total MW mass within 50 kpc has been estimated at 3 $\times 10^{11}$ M$_\odot$ (Kochanek+1996)

2. the rotation curve of the LMC has error bars.