CTA200 Project

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Introduction

The goal of this project is to produce movies of the subhalos in two different simulations. Both of the simulations started from the Via Lactea II halo catalog at redshift 5, and the largest halos were populated with star clusters. In only one of the simulations, a disc potential was added to account for the destructive effect of a central disc on the dark matter substructure. The movies should provide a look at the difference in the number of subhalos near the galaxy center.

Code Description

For each simulation, there are 1232 snapshots of the halos. The code reads in each halo file, extracts the x, y, and z coordinates of each halo's center as well as its radius. To keep the plots centered on the most massive halo, the coordinates of the most massive halo are subtracted from the positions of the halos for each snapshot. A 100kpc by 100kpc x-z plot of each halo file is then created, with the halos represented as circles whose size is determined by the halo's radius, and saved as a png. Finally, the code makes and saves a movie from the x-z plots with ffmpeg.

In addition, I wanted to include a quantitative measure of the subhalos to really appreciate the difference between the two simulations. I made additional movies that contain only the halos within a cube with sides of length 30kpc. The distance of a halo from the center was calculated using the following equation for the radius to count the number of halos within 30 kpc of the galaxy center.

$$r = \sqrt{x^2 + y^2 + z^2} \tag{1}$$

A circle of radius 30 kpc is plotted over the x-z plot and a count of all halos within the sphere of radius 30 kpc centered at (0,0,0) is shown in red.

Snapshots

Figure 1 shows the final locations all of the halos out to 3000 kpc for both simulations. At large distances, the halos in both simulations look the same, as expected. Figure 2 shows the last snapshot for both simulations zoomed in to a 50 kpc radius (the last frame in the first pair of movies). Here is where we can see a difference in the halo abundance. Notice that the "Disc" simulation is missing subhalos compared to the "No Disc" simulation.

While Figures 1 and 2 show x-z projections of the halo positions, Figure 3 shows plots of the halos within a cube of side length 30 kpc centered at (0,0,0). This method of plotting the subhalos gives a better representation of the amount of subhalos in the inner region of the galaxy, since it places a limit on the y-coordinate along with the x and z-coordinates, whereas in the first 4 figures, the x-z projection flattens all of the y-coordinates onto the y=0 plane. In Figure 3, the red circle indicates a radius of 30 kpc, while the number in red represents the number of subhalos within a sphere of 30 kpc centered at (0,0,0). The number of subhalos (59 for the Disc simulation and 99 for the No Disc simulation) matches subhalo counts previously obtained from cumulative mass distributions I calculated in previous assignments.

In the movies, you can see the number of subhalos in the frame decreasing with time. This can be seen particularly well in the

`359halos_30kpc.mp4`

and

`360halos_30kpc.mp4`

movies, as the number in red that indicates the number of subhalos within a sphere of radius 30 kpc gets smaller as the movie plays. This is due to the expansion of the simulation, causing the space between the subhalos to increase. In the Disc simulation, this decrease is also due to the tidal effects of the embedded disc potential destroying subhalos in the innermost region of the simulation galaxy.

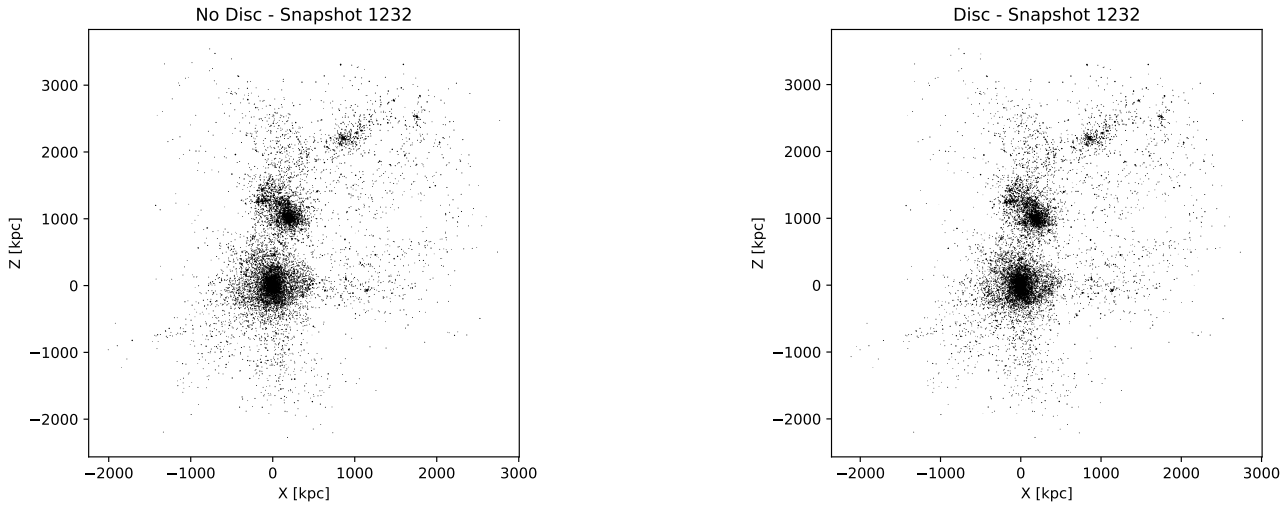

Figure 1: Plots of the halos from the last snapshot. On the left is all of the halos in the "No Disc" simulation, and on the right is all halos in the "Disc" simulation. At this distance, the difference between the simulations is undetectable.

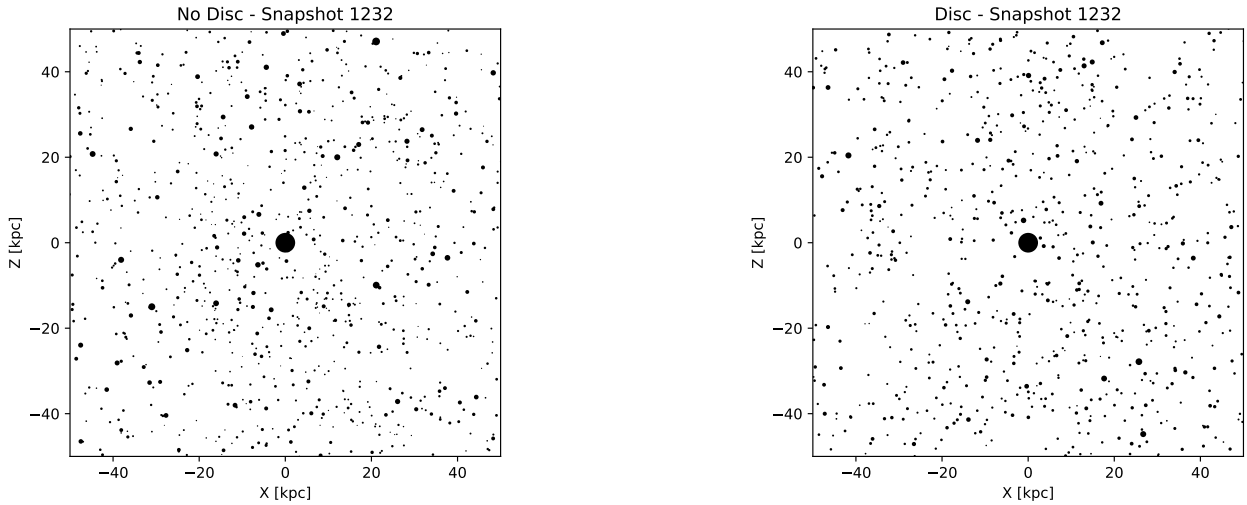

Figure 2: Plots of the final snapshots of both simulations at a radius of 50 kpc. The size of the marker is proportional to the radius of the halo. Notice the Disc simulation (left) has fewer tiny halos than the No Disc simulation (right).

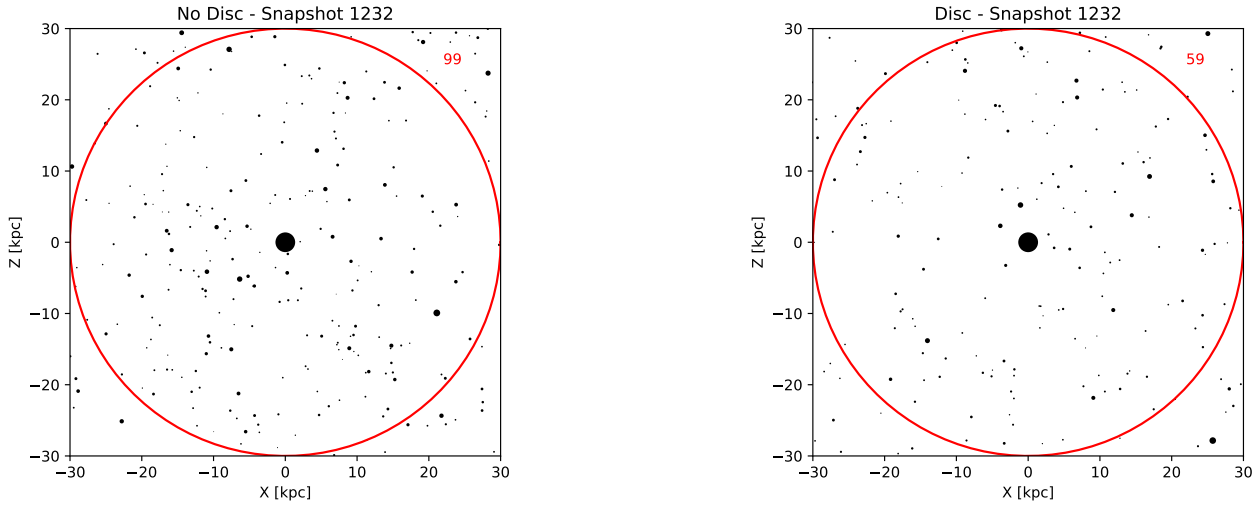

Figure 3: Plots of the final snapshots of both simulations at a radius of 30 kpc. Again, the size of the marker is proportional to the radius of the halo. The number of subhalos within a radius of 30 kpc from the center is given in red in the top right of both plots. The Disc simulation has 40 fewer subhalos in this inner region, due to the destructive tidal forces of the disc potential.