ASTP-720 Homework 5

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Github Link: `https://github.com/zrd7527/ASTP720.git`

1 Problem 1

For this problem I created a node class to store data and make a tree structure for the Barnes-Hut algorithm. Each node stores a data array in the form of individual x and y coordinate arrays, a center, a length, an array of the data in each quadrant, and an array of child nodes. The data is originally given as an array which is a 10 Mpc square 'box'. This box is input into the node class and recursively broken up into separate quadrants until the leaf nodes with only one data point are found and stored. The leaf nodes are then plugged into a function which finds the distance from each leaf center of mass to the branch center of mass. If the branch center of mass is within the limiting opening angle then the next level of branches is checked and the change in position of all points outside of the limiting opening angle are approximated. The leaf nodes within the limiting opening angle are individually plugged into my Verlet algorithm function for direct summation of their motion. Approximated data have their branch's center of mass plugged into the Verlet algorithm. Any leaf node data point inside of my defined distance epsilon have force softening used to update their distance. The plot of the final galaxy positions has some galaxies which move very far from the cluster. This may be a problem with my force softening equation or the way I step through the tree to update each data point's position. The starting and ending positions of the galaxies can be seen in Figures 1 and 2 respectively.

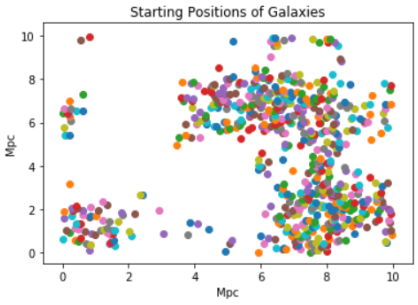

Figure 1

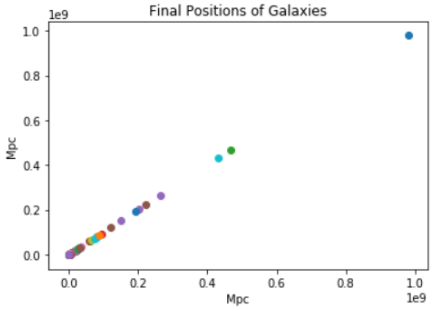

Figure 2

2 Problem 2

I started this problem by initializing a 2D array spanning a 10 Mpc square grid. I then calculated the mass enclosed within the radius of each point on the grid from the center of the clusters. The points outside of the clusters had all of the mass enclosed whereas points inside of the clusters only had a part of the mass enclosed. The amount of mass enclosed is proportional to the radius that the point is from the center. This is because the clusters are assumed to be uniform density. The gravitational potential is then calculated for each point and plotted with matplotlib's imshow function. The result can be seen in Figure 3.

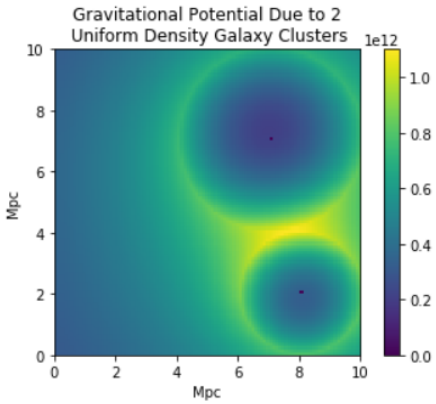

Figure 3