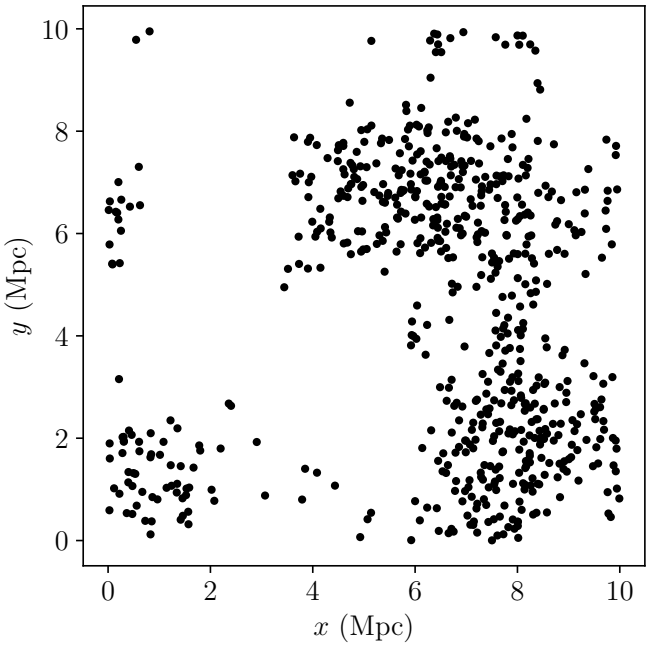
ASTP 720 - Homework 5 - Universe in a (2D) Box

Due October 8th, 2020

Your goal is to study the dynamics of a cluster of galaxies. In the file `galaxies0.npy` is an array representing the x and y coordinates of 655 simulated galaxies and `galaxies1.npy` is an array representing the same galaxies 1000 years later (you need not choose this value as your timestep though). You may assume each galaxy has the same mass, which you can take to be $10^{12}\ M_\odot$.

The simulation at $t = 0$ looks like this:



Your tasks:

[1.] Using the Barnes-Hut algorithm and your favorite symplectic integration method, evolve the system into the future, at least enough for particles to move of order Mpc if not more. You should include force softening of some form. In your write-up, make sure when you describe your method that you describe your parameters. Please include an image that shows the positions of a few of the galaxies at the start to whenever you end your simulation.

[2.] You want to understand the crude potential of this cluster to understand how a new galaxy might interact with it. Pretend that all 655 galaxies are distributed into two groups, one centered at (7, 7) Mpc and one centered at (8, 2) Mpc. Take the first clump to have 400 galaxies uniformly distributed in a circle with radius 3 Mpc and the second to have the other 255 distributed in a circle with radius 2 Mpc (i.e., imagine uniform density "balls"). Calculate the gravitational potential throughout the box and make a 2D plot. Note that at the boundaries of the cube, the potential should be zero.