N-body simulations with Gadget-2

Simulation and visualization of large scale structure

Fifth report

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1 Introduction

Gadget-2 is a freely available code for cosmological simulations [1]. I have read this name several times in scientific papers, and it is marginally connected to my research, so I would like to understand it and see how it works. I hope, this will help me when I use similar codes and packages.

After installing Gadget-2 I ran a test program, the collision of galaxies, then I started the simulation of large scale structures. Before this week I installed packages that can generate initial conditions for the large scale structure simulation: N-GenIC and 2LPTic. I also generated a glass and initial condition from this glass with N-GenIC, then I could run the large scale structure simulation and make some plot with Python. These are detailed in the previous reports.

In this report I describe the large scale structure simulation highlighting my progress in this week. In section 2 I overview the simulation. Section 3 contains some figures I made with Python. Section 4 shows the first steps of the comparision of the simulation and observations. I summarize my work in section 5.

2 Simulation of large scale structure

In cosmology the study of large scale structures is a very important task. The simulations can be compared with the observations, thus we can give the cosmological parameters. The Gadget can help with these simulations [2].

In the previous weeks I installed two initial condition generator: the first order N-GenIC based on Zeldovich approximation [3] and the second order 2LPTic Lagrangian Perturbation Theory [4] and made a glass with Gadget-2. The glass can satisfy the cosmological principles, the isotropy and the homogenity, which is essential in cosmological simulations. There are some (dark matter) particle, when we make glass, we turn on an anti-gravity. If we made the initial condition from a grid, the isotropy would not be true.

After that I created initial condition from this glass with N-GenIC. When I ran the simulation, it was important that the parameters I set have to agree in the parameterfiles of the Gadget-2 and the initial condition generator.

I ran the simulation with the following parameters in the parameterfile of Gadget-2:

- TimeBegin 0.0008975124
- TimeMax 1.0
- BoxSize 150000.0

and in the parameterfile of the initial condition generator:

- Nmesh 100
- Nsample 100
- Box 150000.0
- TileFac 2
- Redshift 1000

I did not change the other parameters. The result is shown in Figure 1 visualized by Gadgetviewer. I also made a video from the saved snapshots with the help of an online video maker [5]. I uploaded it to the github repository I made for this course [6].

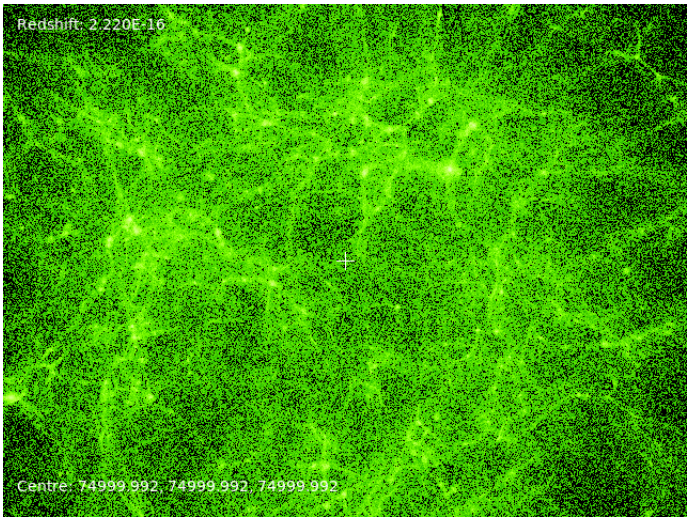

Figure 1: The result of the large scale structure simulation visualised by Gadgetviewer.

3 Visualisation

To make nicer plots with Python I installed pygadgetreader according to [7]. In this section I would like to include some plots I made with matplotlib.pyplot and mpl_toolkits.mplot3d.

The comparision of the glass and the initial conditions is shown on Figure 2. I made a 3D plot about the result (Figure 3), but in this case we cannot see well the structure because it is projected in 2D. I also plotted the y-positions as the function of x-positions of the large scale structure (Figure 4), but here again we might see the different depths in the same plane. Therefore I created pictures from a given 'z' interval (a slice of the snapshot): Figure 5, 6, 7, and 8.

4 Comparison with observational data

I would like to make a similar plot as the picture in Park et al. 2005. [8] (Picture 9). First I choose the origo of the coordinate system into the middle of the cube. Then I change the Descartes coordinates into spherical polar coordinates, and change from radians to degrees. I fixed the φ angle between 100° and 106°. I made the plot with the help of [9]. The result is shown on Picture 10. I am not sure that this plot is good for the comparision, because the structure one can see in the observational data is not shown in my picture.

5 Discussion, following steps

In this week I made some new plots about the large scale structure simulation. I started to make a plot for the comparision of the simulation and observations.

In the next week I would like to finish the comparision, write the midterm report and prepare to the midterm presentation.

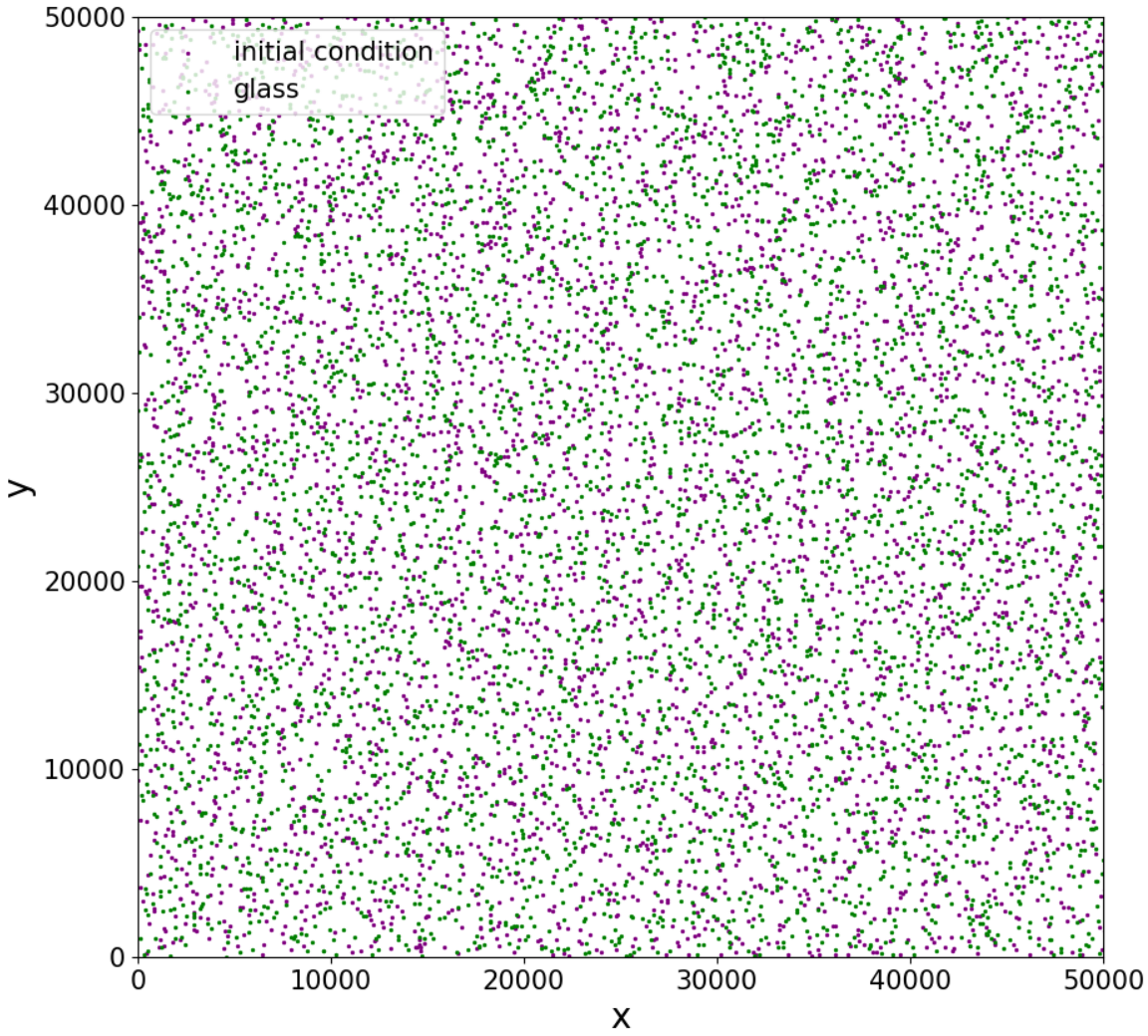

Figure 2: The position of the particles in the glass (green dots) and in the initial condition (purple dots) plotted in the region where we can compare them. I plotted here every 200th particle.

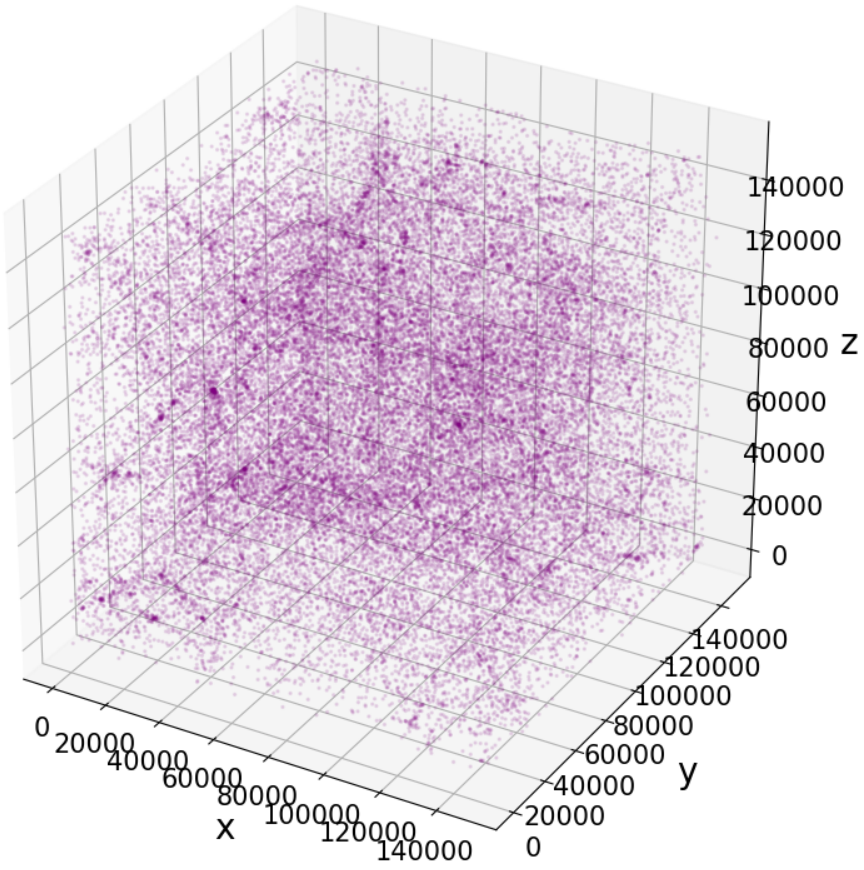

Figure 3: A 3D plot about the large scale structure. I plotted here every 200th particle.

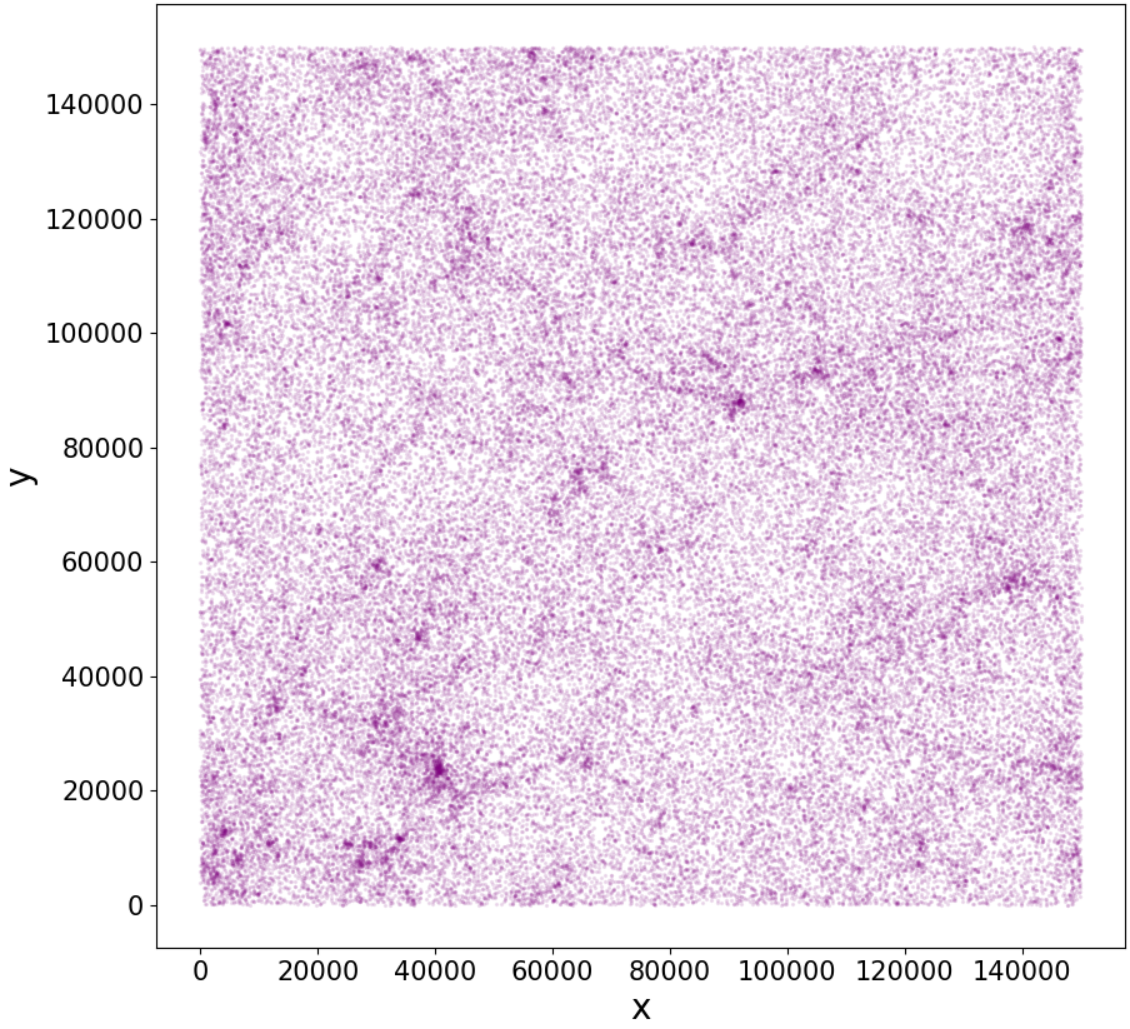

Figure 4: A 2D plot about the large scale structure. I plotted here every 100th particle.

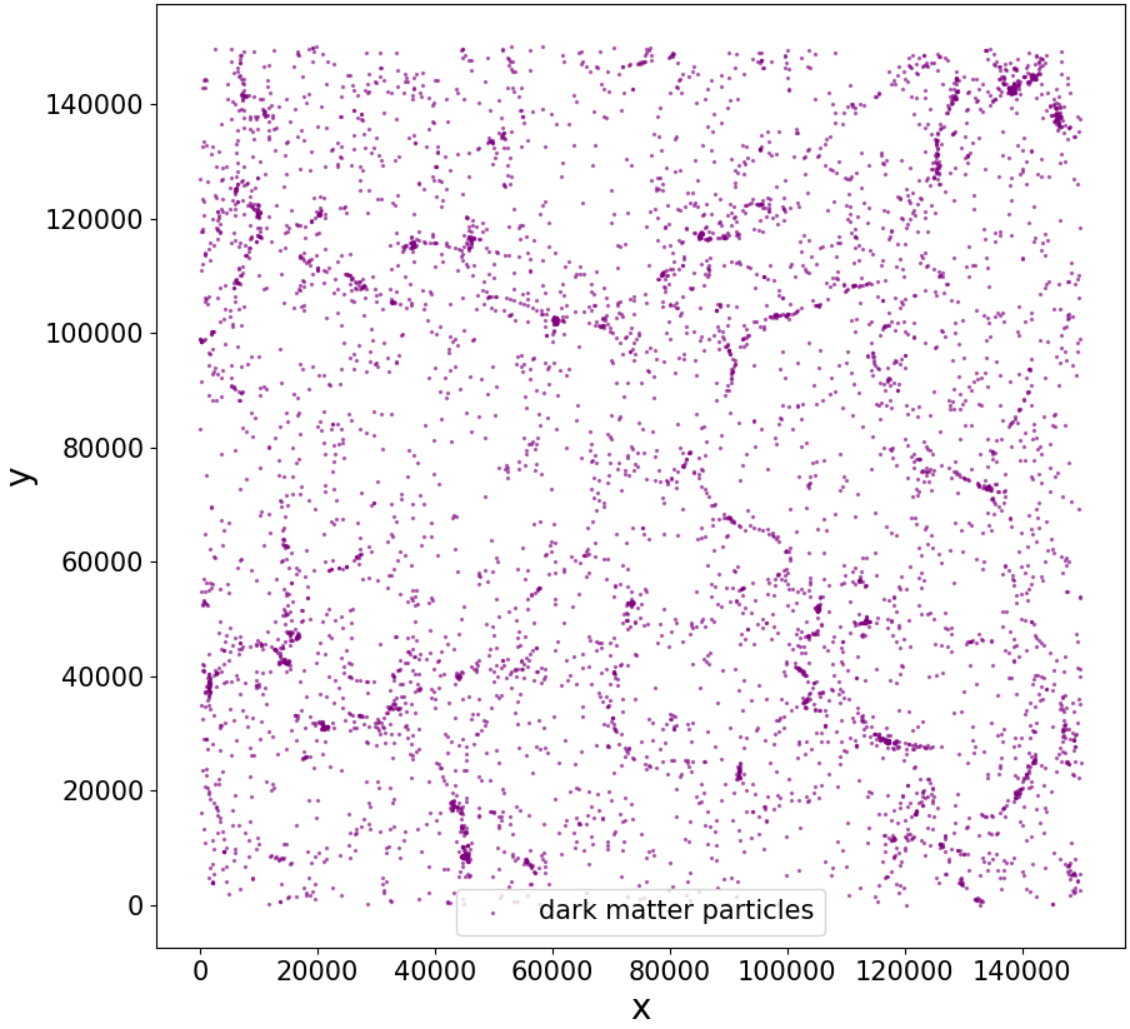

Figure 5: A 2D plot about the large scale structure, if $100 < z < 200$.

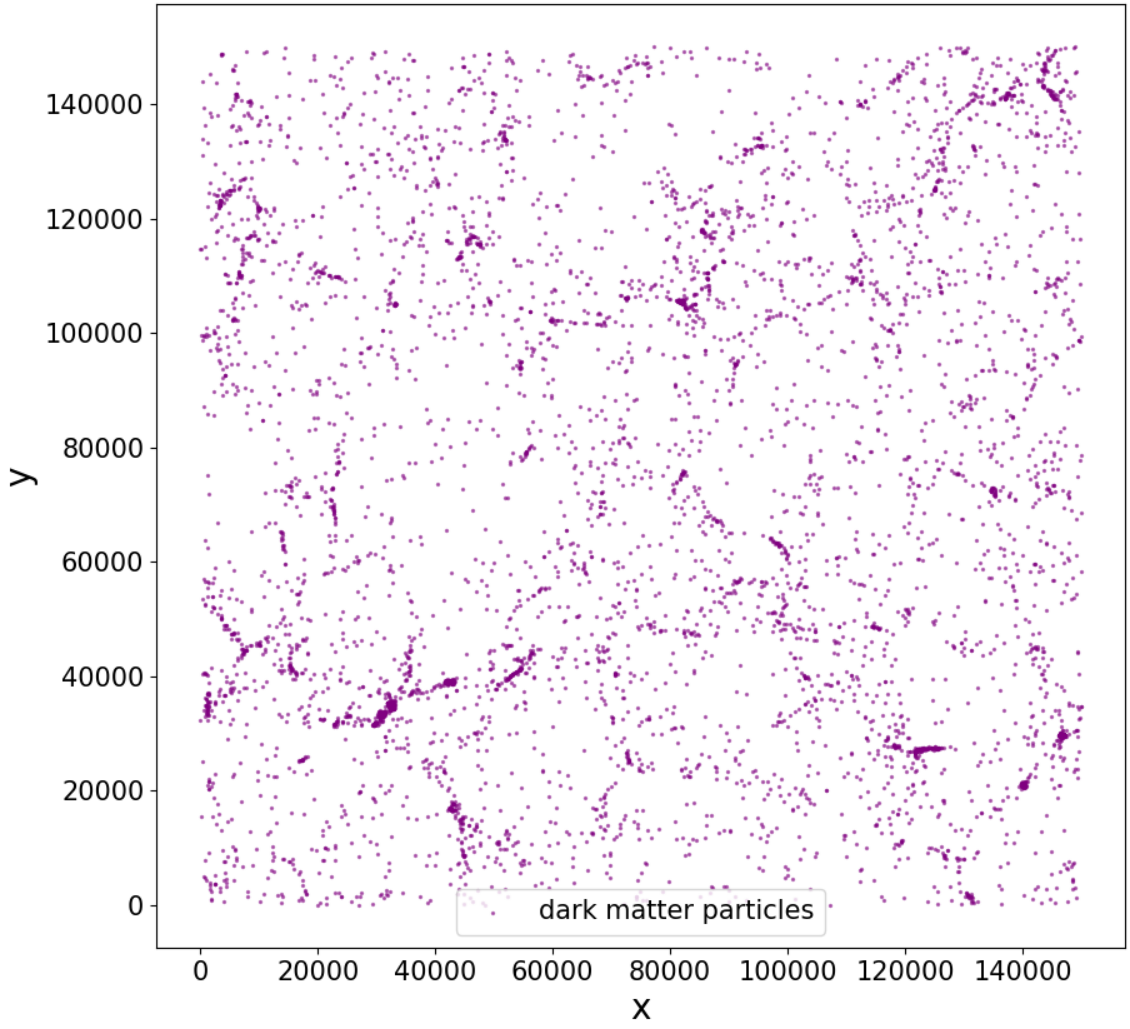

Figure 6: A 2D plot about the large scale structure, if $1000 < z < 1100$.

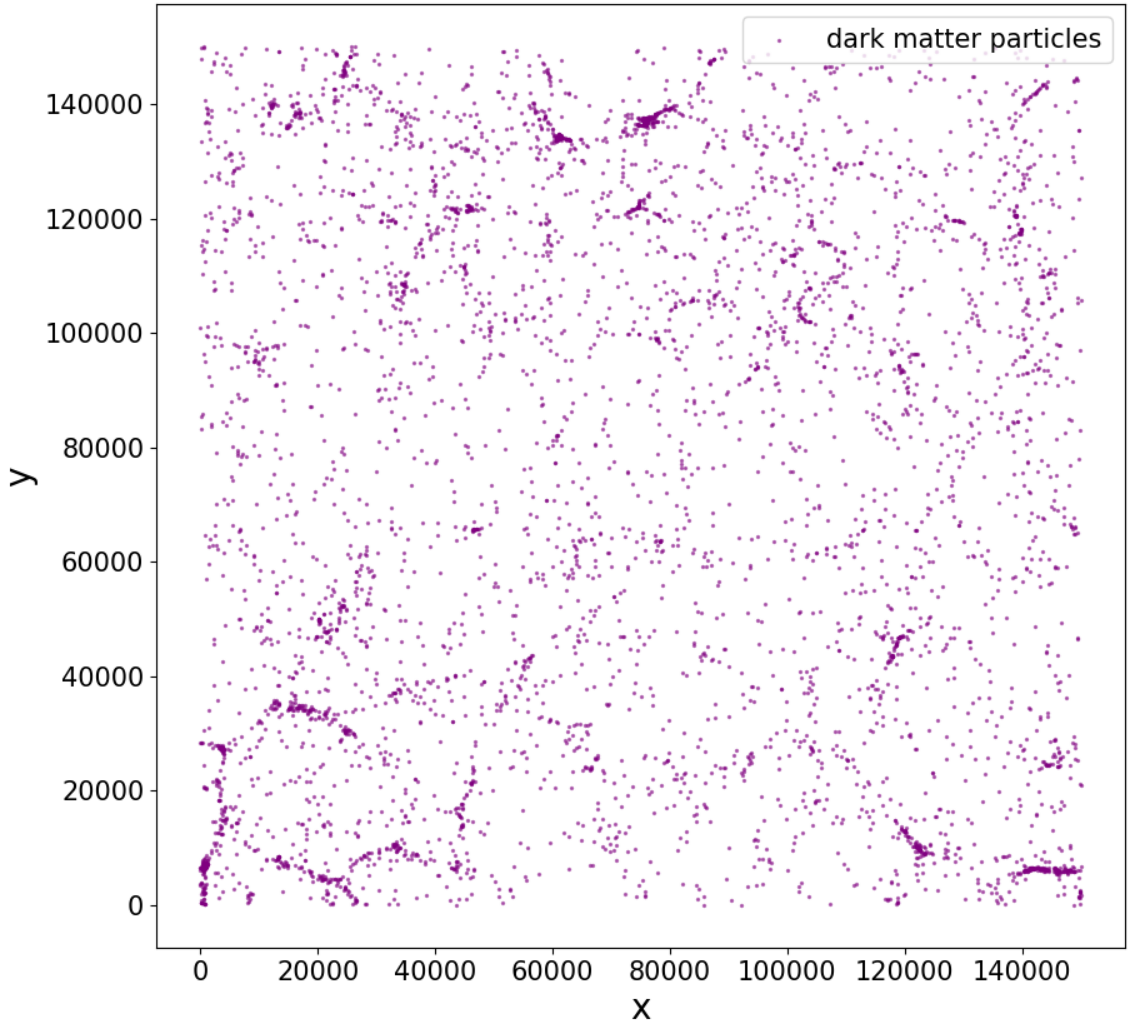

Figure 7: A 2D plot about the large scale structure, if $10000 < z < 10100$.

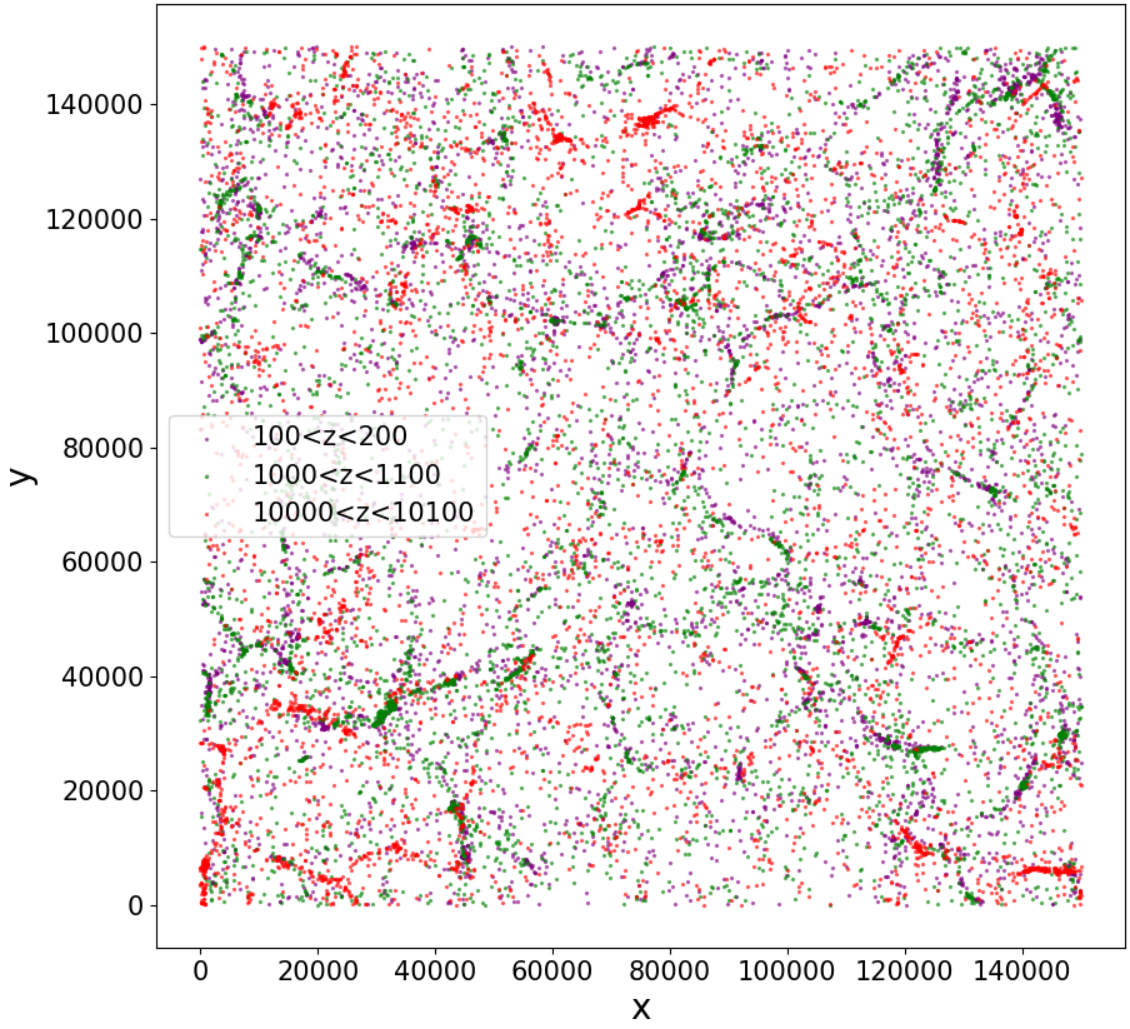

Figure 8: A 2D plot about the large scale structure at given z coordinates.

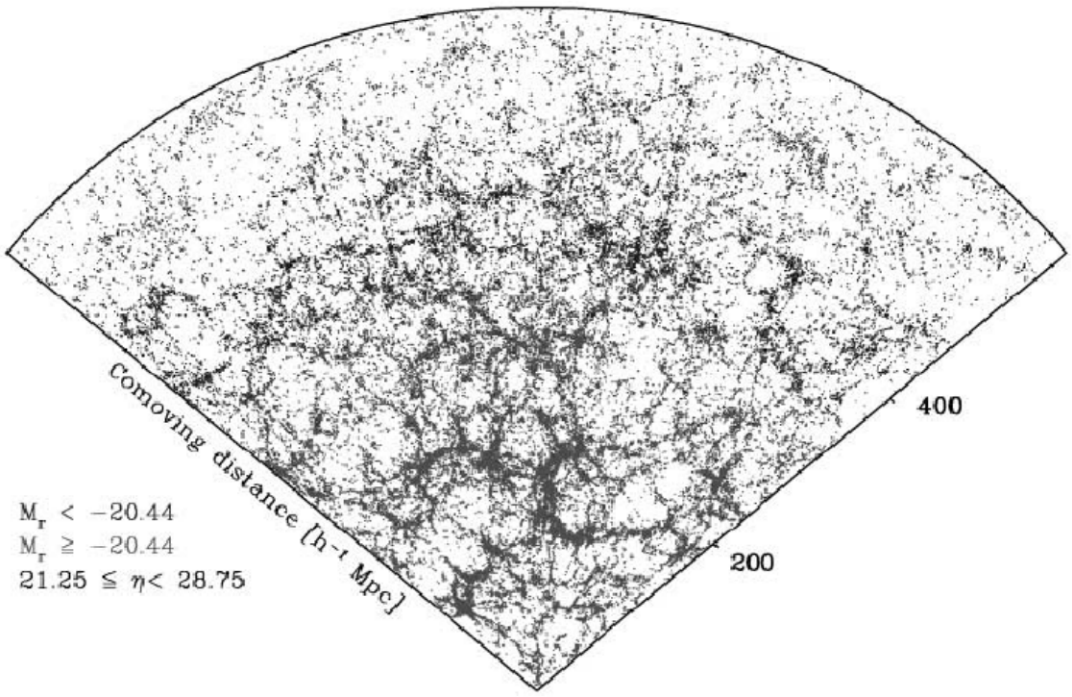

Figure 9: Picture from Park et al. 2005.

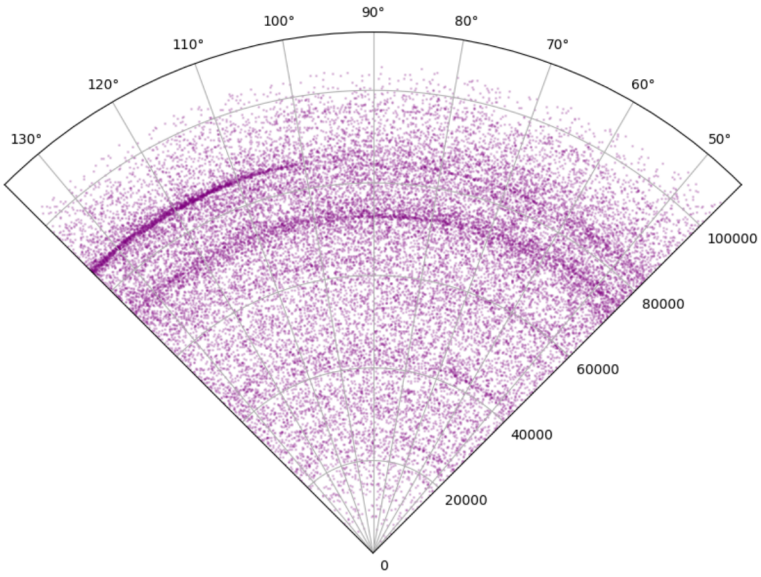

Figure 10: Picture for the comparision with the observational data.

References

[1] https://wwwmpa.mpa-garching.mpg.de/gadget/

[2] https://wwwmpa.mpa-garching.mpg.de/galform/millennium/

[3] Springel, V., White, S. D. M., Jenkins, A., Frenk, C. S., et al. 2005, Nature 435, 629–636

[4] Crocce, M., Pueblas, S., Scoccimarro R., 2006, MNRAS 373, 369–381

[5] https://ezgif.com/apng-maker

[6] https://github.com/MariaPalfi/Scientific-modelling-lab/blob/master/lss_evol.gif

[7] https://bitbucket.org/rthompson/pygadgetreader/src/default/

[8] Park et al. 2005, ApJ, 633, 11

[9] https://matplotlib.org/3.1.1/gallery/pie_and_polar_charts/polar_scatter.html