N-body simulations with Gadget-2

First simuation of large scale structure

THIRD REPORT

Pálfi Mária

Physics MSc 2. semester

February 29, 2020

SCIENTIFIC MODELLING COMPUTER LAB

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.

I have already installed the Gadget-2 during the first week of the semester (the details can be read in the first report). The previous week I installed Gadgetviewer and made videos about the collision of galaxies, then I downloaded and installed packages which can generate initial conditions for the large scale structure simulation: N-GenIC and 2LPTic (detailed in the second report).

In this report I describe the progress of this week. In section 2 I give some correction to the visulaisation of galaxy collision. Section 3 contains the method of how to simulate large scale structures. I summarize my work in section 4.

2   Collision of two galaxies

Collision of galaxies is an important question of evolution of galaxies [2]. The future collision of the Milky Way and the Andromeda is a well-known phenomena and we can search on the net for beautiful Hubble Space Telescope Images of colliding galaxies but even in the last few years some articles were born on this topic like [3] and [4]. [5] used GADGET code to simulate three merging disk galaxies.

The test program for Gadget-2 is collision of two galaxies. In the first report I showed I could run the command and I got some snapshots and the previous week I could visualise them. In this week I create a github repository and upload the videos I made: https://github.com/MariaPalfi/Scientific-modelling-lab. I made some new videos that do not contain the dark matter, therefore we can see what we could in the real world. These are also uploaded to the github repository. I used [6] to create the gif files.

3 Large scale structure simulation

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 [7].

In the previous week I installed two initial condition generator: the first order N-GenIC based on Zeldovich approximation [8] and the second order 2LPTic Lagrangian Perturbation Theory [9]. In this week I made a glass with Gadget-2 and then create initial conditions from this glass with N-GenIC. Then I tried to start a cosmological simulation with Gadget, but it does not work yet.

The glass can satisfy 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.

First, I edited the Makefile in the Gadget2 directory, I turned on

```
OPT   +=   -DMAKEGLASS=1000000
```

option, then I wrote *make* in the commander line. So the Gadget-2 could create a glass. Then I copied the parameterfile *lcdm_ gas.param* and named lss.param. I ran Gadget with this parameterfile. I got some snapshot as result, the latest is shown in Figure 1.

Then I create an initial condition with this glass with NGenIC by setting the latest glass snapshot as *GlassFile*. This made small perturbations in the glass, where we can start the simulations.

I turned off the -DMAKEGLASS option in the Makefile of Gadget2, then run *make*. I made a new parameterfile where I gave the initial conditions *InitCondFile*, I tried to run the Gadget2 with this parameterfile, but I got the next message:

```
I've found something odd!
---------------------------------------------------------------------------
MPI_ABORT was invoked on rank 1 in communicator MPI_COMM_WORLD
with errorcode 1.


NOTE: invoking MPI_ABORT causes Open MPI to kill all MPI processes.
You may or may not see output from other processes, depending on
exactly when Open MPI kills them.
```

```
------------------------------------------------------------------------
The mass content accounts only for Omega=8.1,
but you specified Omega=0.3 in the parameterfile.


I better stop.
task 0: endrun called with an error level of 1
```

I could not solve this problem yet.

4   Discussion, following steps

In this week I made new videos about the galaxy collisison and started to make a large scale structure simulation. I also started the installation of Gadget-2 to the Atlasz server.

In the next week I would like to solve the problem with the large scale structure simulation mentioned in Section 3 and finish the simulation.
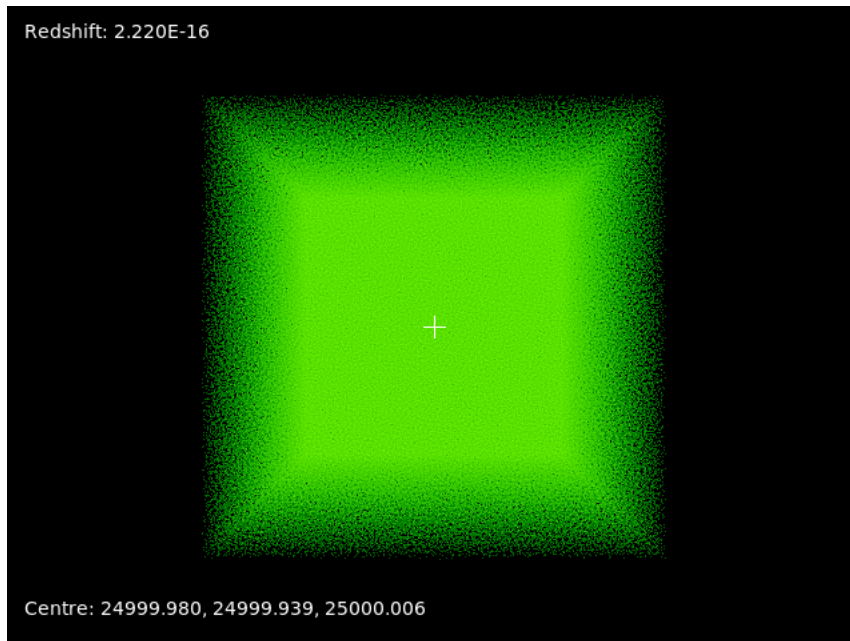

Figure 1: Glass made with Gadget-2.

References

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

[2] https://en.wikipedia.org/wiki/Interacting_galaxy#Galaxy_collision

[3] Calabrò, A., Daddi, E., Fensch, J., Bournaud, F., et al. 2019, A&A 632, A98

[4] Chen, Guangwen; Wu, Xufen; Kong, Xu; Liu, Wen-Juan; Zhao, HongSheng, 2018, ApJ, 864, 1

[5] Kotarba, H., Lesch, H., Dolag, K., Naab, T., et al. 2011, MNRAS, 415, 3189

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

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

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

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