# N-body simulations with Gadget-2

Visualisation of collision of galaxies and installation of initial conditions

First report

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Physics MSc 2. semester

February 29, 2020


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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.

I have already installed the Gadget-2 during the previous week (the details can be read in the first report). In this report I describe the progress of this week. Section 2 discusses the collision of galaxies and how I visualised them. In section 3 I detail the installation of the initial conditions to my laptop. In section 4 I describe the first steps towards using the supercomputer of ELTE, the Atlasz. I summarize my work in section 5.

# 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, but I could not look into these. The progress of this week was that I installed Gadget File Viewer [6]. To do this I had to have GTK+ 2.0 GUI library, I installed it with the

```
sudo apt-get install gtk+2.0
```

command. I downloaded the compressed gadgetviewer file from [7], then I tried to install it according to [8], but it did not work. I solved the problem by following the steps of the installation guide of mpich [9] which I used in the previous week.

I can open the program with the gadgetviewer command in terminal. To see the snapshots I choose the Read Gadget snapshot... from File menu and browse the files. I can choose the orientation by pushing its button and make a video by choosing Options/Make a movie... (see Figure 1). The gadgetviewer converted the snapshots to png, these are shown in Figure 2, 3 and 4. I made three .gif videos from three different orientations by concatenating the png files with the help of an online video maker [10].

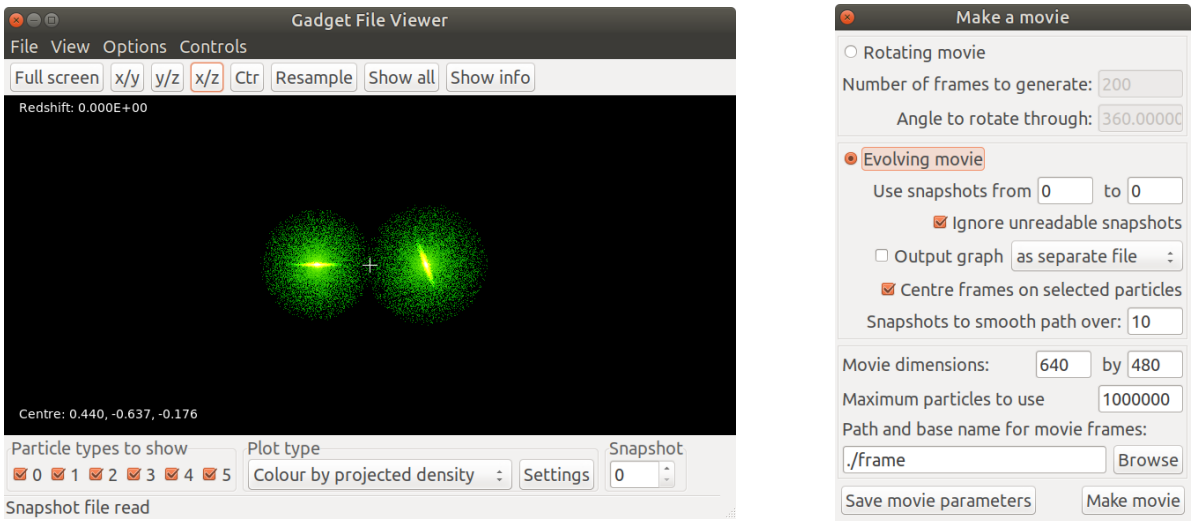


Figure 1: The Gadget File Viewer program and Make a movie panel.

# 3 Initial conditions for cosmological simulations

In the following weeks I would like to simulate the formation of the large scale structure of Universe, therefore I need to have programs generating appropriate initial conditions.

## 3.1 First-order initial conditions

I installed **N-GenIC** which based on the first-order Zeldovich approximation, and gives the initial conditions in a format directly compatible with Gadget [11]. I could not download the compressed file from the given website [12], but I found it on [1]. I read the README and gave the directory pathes in the Makefile. I commanded make to install it, but I got the next error message:

```
main.c:3:10: fatal error: drfftw_mpi.h: Nincs ilyen fájl vagy könyvtár
#include <drfftw_mpi.h>
```

So I started to look for what is this file and found on [13] that I have to install FFTW in both single and double precision, therefore I did it according to this webpage.

I tested my installation with the

```
mpiexec -np 8  ./N-GenIC  ics.param --mca orte_base_help_aggregate 0 ...
```

command, after I made the necessary ICs directory, it ran properly (Figure 5).

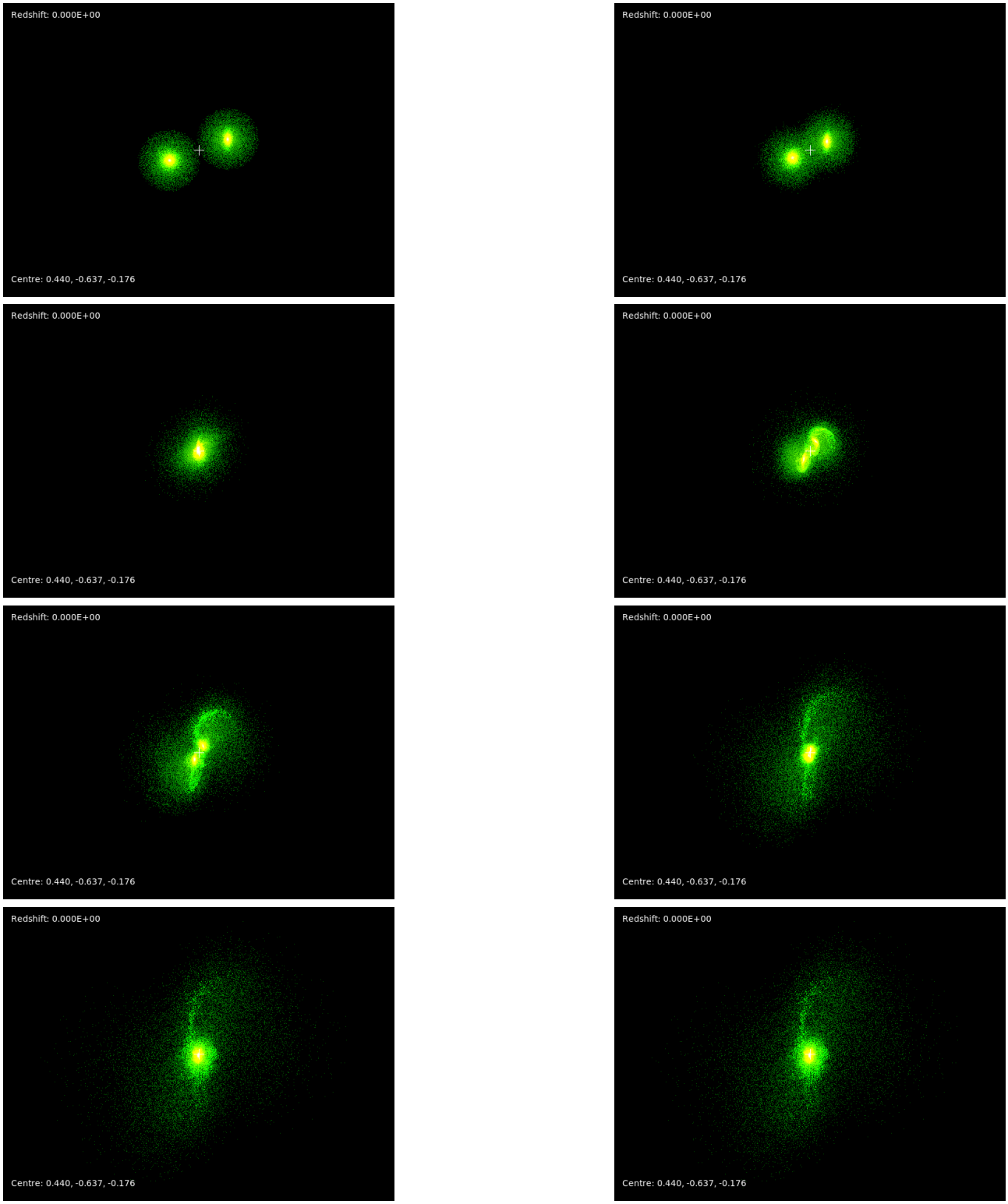


Figure 2: xy projection of the collision of two galaxies visualised by gadgetviewer.

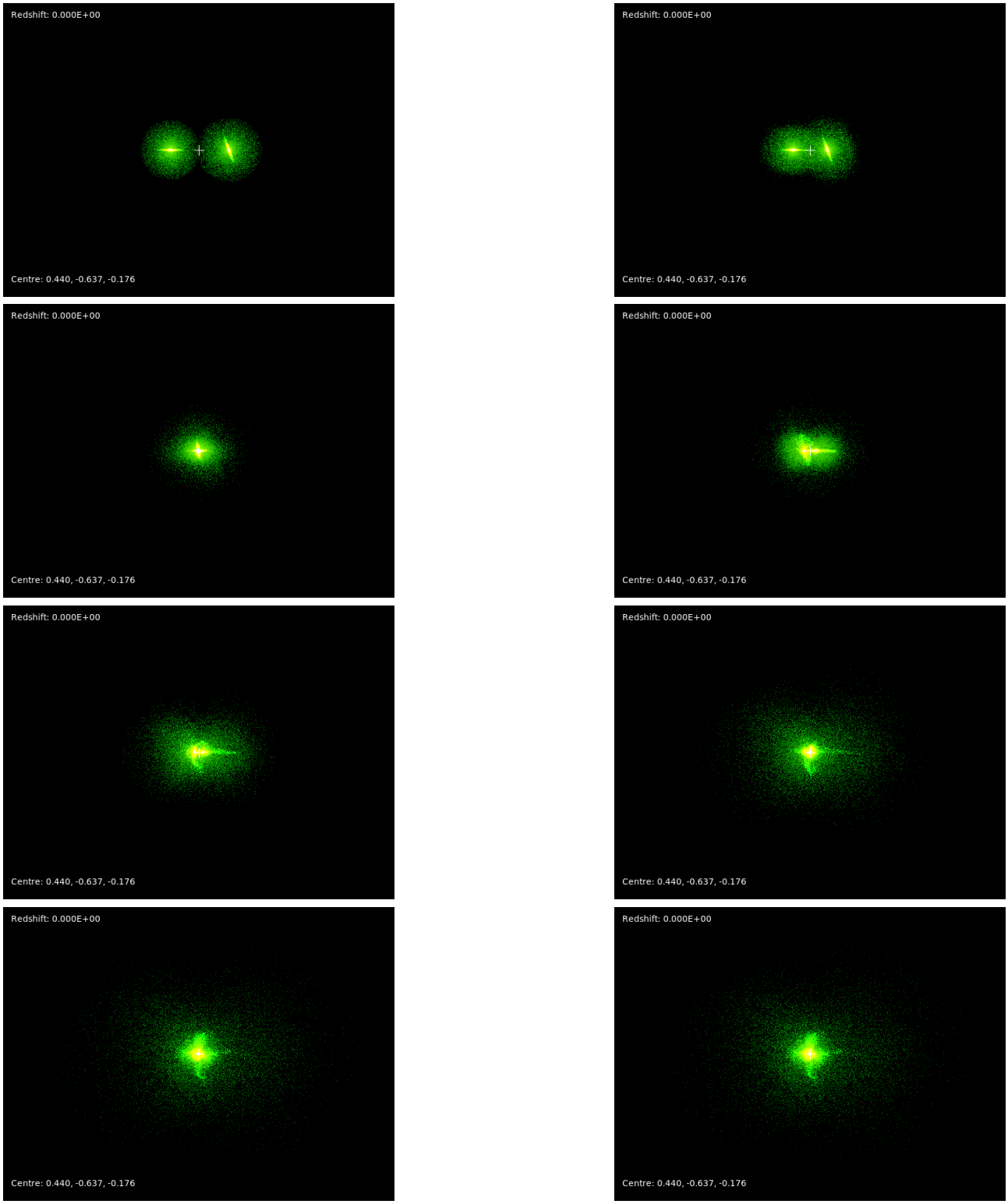


Figure 3: xz projection of the collision of two galaxies visualised by gadgetviewer.

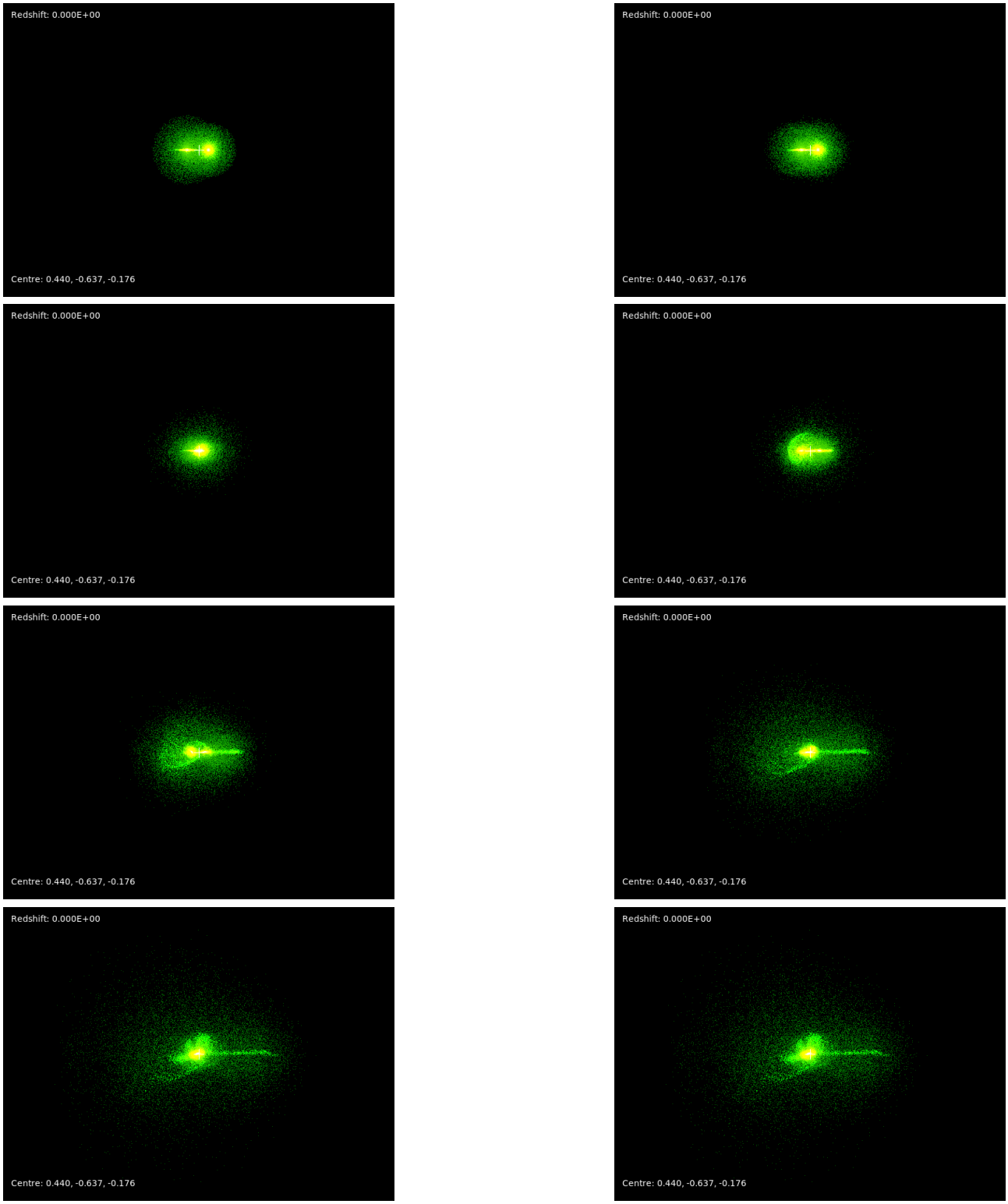


Figure 4: yz projection of the collision of two galaxies visualised by gadgetviewer.

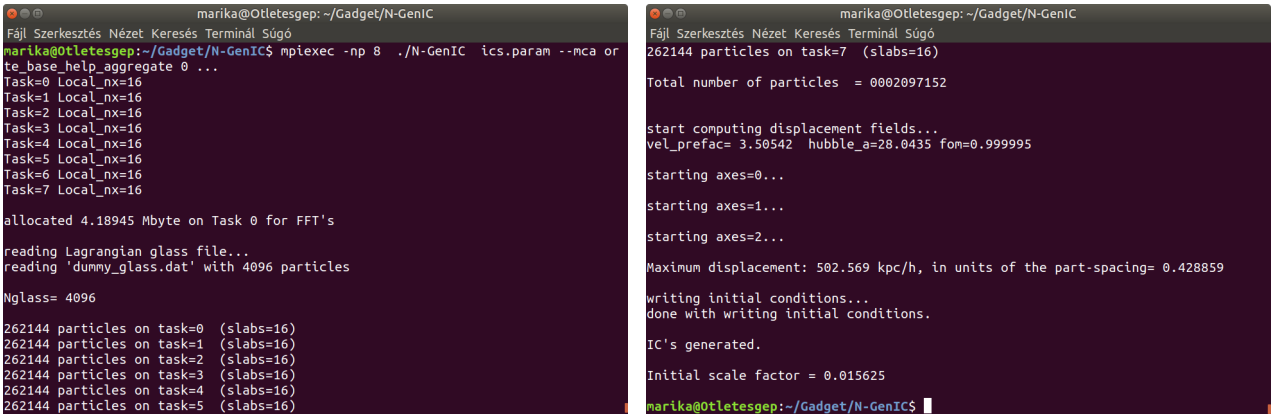


Figure 5: Testing the installation of N-GenIC.

## 3.2 Second-order initial conditions

Sometimes we use second-order initial conditions [14], therefore I installed MPI-parallel version of **2LPTic** based second-order Lagrangian Perturbation Theory. I downloaded the version for Gaussian initial conditions from [15]. I installed it with editing the Makefile in a similar way as the N-GenIC.

I tested the installation with the example of [15]. Here I had to also give the proper directory pathes, then I could run the command, but I do not have enough memory, thus my computer died (Figure 6).

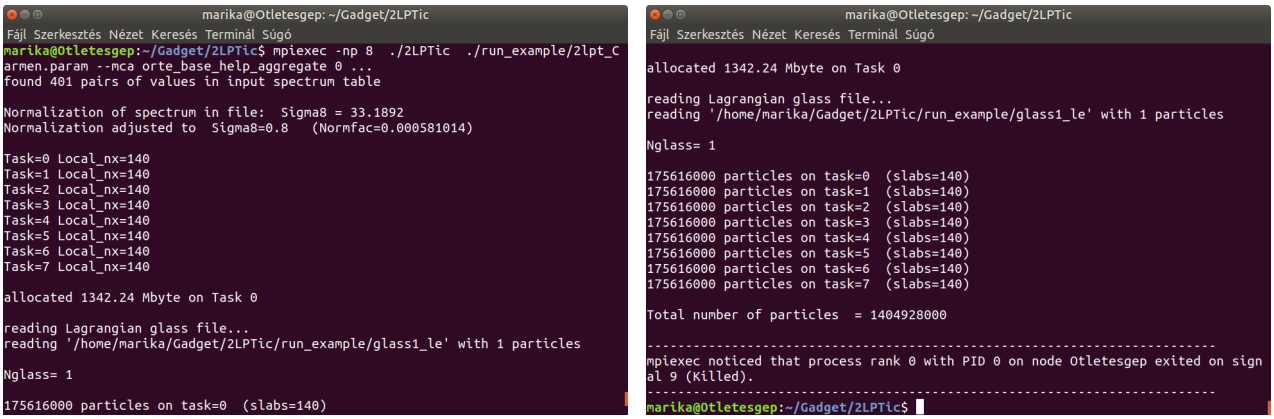


Figure 6: Testing the installation of 2LPTic.

# 4 Atlasz

To avoid the memory problem it is common to use supercomputers. I submitted the application form for the hpc (high-performance computing) [16] in the office of IIG. Now I can login using ssh to the Atlasz server of ELTE. My next task is installing all the packages I installed to my laptop to the Atlasz server.

# 5 Discussion, following steps

In this week I successfully installed gadgetviewer and made videos about the collision of galaxies. I could also install the initial condition packages for large-scale structure simulations to my laptop.

I could submit for the hpc only on Thursday, so I did not installed the packages to the Atlasz server, I am going to do this in the next week.

# 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] http://astro.dur.ac.uk/~jch/gadgetviewer/index.html

[7] https://github.com/jchelly/gadgetviewer/releases

[8] https://github.com/jchelly/gadgetviewer/blob/master/README.md

[9] https://www.mpich.org/static/downloads/3.3.2/mpich-3.3.2-installguide.pdf

[10] https://deparkes.co.uk/2018/01/05/create-video-images-ffmpeg/

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

[12] https://www.h-its.org/2014/11/05/ngenic-code/

[13] http://www.fftw.org/fftw2_doc/fftw_6.html

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

[15] https://cosmo.nyu.edu/roman/2LPT/

[16] https://hpc.iig.elte.hu/dokuwiki/doku.php