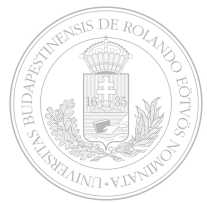
Report on the Computer-Aided Modeling Lab

Simulations using GADGET-2 and OpenFOAM

Balázs Pál

Eötvös Loránd University

Computer-Aided Modeling Lab,
January 5, 2021



Projects and goals

- **GADGET-2**
  - Simulate an isolated, rotating galaxy with and without dark matter
  - Compare their rotation curves to each other and to reality

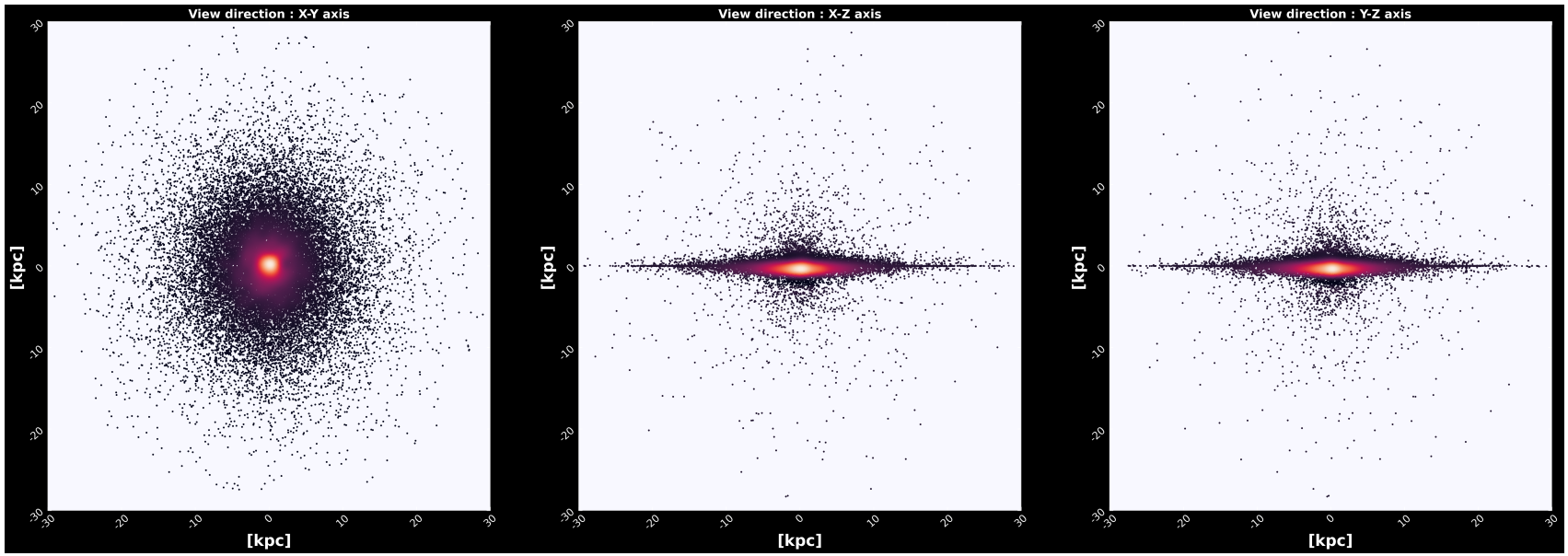


Figure 1: Initial conditions of my rotating galaxy simulation, where only those particles are shown, which are part of the bulge, gas or disk parts of the galaxy. The particles of the halo are hidden here.

Projects and goals

- **OpenFOAM**
  - Create a water droplet simulation, where a water droplet hits the surface of water inside a rectangular vessel

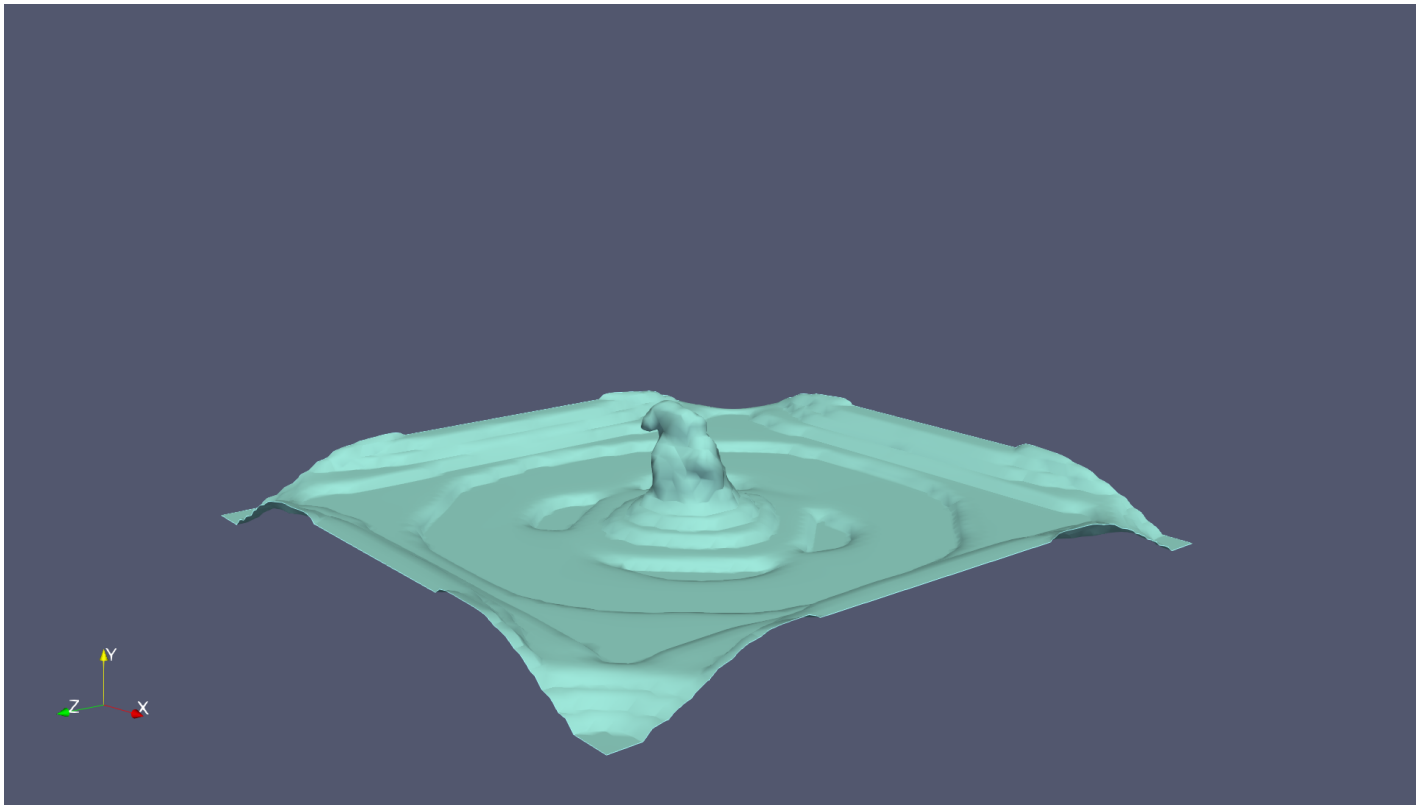
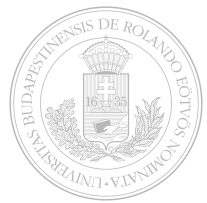


Figure 2: A snapshot from the water droplet simulation, after the droplet hit the surface of the water. The borders of the vessel are rendered invisible.

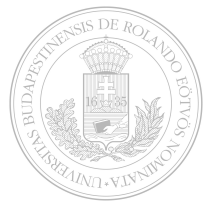
Project I – GADGET-2 – Initial problems

1. Download, build and execution requires a handful of attention



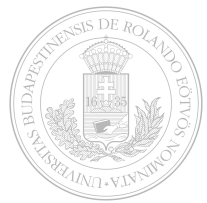
Project I – GADGET-2 – Initial problems

1. Download, build and execution requires a handful of attention
   - Numerous legacy prerequisites
   - Compatibility problems or unnecessarily complicated build process on eg. Windows
   - Initial conditions (ICs) and myriads of simulation parameters need to be set carefully



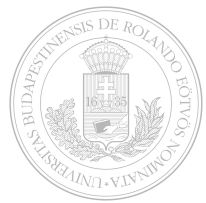
Project I – GADGET-2 – Initial problems

1. Download, build and execution requires a handful of attention
   - Numerous legacy prerequisites
   - Compatibility problems or unnecessarily complicated build process on eg. Windows
   - Initial conditions (ICs) and myriads of simulation parameters need to be set carefully
2. IC generation and encoding should be made entirely manually, there is no such thing as an "easy editing tool" (like OpenFOAM does `blockMesh` and others)



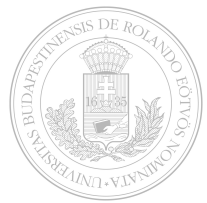
Project I – GADGET-2 – Initial problems

1. Download, build and execution requires a handful of attention
   - Numerous legacy prerequisites
   - Compatibility problems or unnecessarily complicated build process on eg. Windows
   - Initial conditions (ICs) and myriads of simulation parameters need to be set carefully
2. IC generation and encoding should be made entirely manually, there is no such thing as an "easy editing tool" (like OpenFOAM does `blockMesh` and others)
3. Requires parallel computation even for "easier" problems



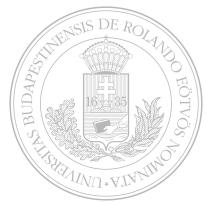
Project I – GADGET-2 – Project description

1. **Simulation goals**
   - Simulate a single, isolated, rotating galaxy and measure its rotation curve
   - Consider two cases: first where there is is no halo, and second where there is (associate dark matter with the halo of the galaxy)



Project I – GADGET-2 – Project description

1. **Simulation goals**
   - Simulate a single, isolated, rotating galaxy and measure its rotation curve
   - Consider two cases: first where there is is no halo, and second where there is (associate dark matter with the halo of the galaxy)
2. **Expectiations**
   - In the normal, **dark matter case** we expect, that the galaxy will be **stable** and have a **regular** rotation curve
   - In the **halo-less case** we expect, that the galaxy's behaviour will be highly **unstable** for the same IC as in the previous case and would fall apart very soon



Other forms of Amdahl's laws

(Embarassingly just from Wikipedia)

- Optimizing the sequential part of parallel programs

$$Q_{\text{speedup}}(O, N) = \frac{\frac{S}{O} + (1 - S)}{\frac{S}{O} + \frac{1-S}{N}}, \tag{1}$$

where O is the speedup of the sequential runtime, so $T_{S_{\text{new}}} = T_{S_{\text{old}}}/O$.

- Transforming sequential parts of parallel programs into parallelizable

$$Q_{\text{speedup}}(O', N) = \frac{1}{\frac{S}{O'} + \left(1 - \frac{S}{O'}\right)\frac{1}{N}}, \tag{2}$$

where S is reduced by a factor of O', so $S_{\text{new}} = S_{\text{old}}/O'$.