Report on the Computer-Aided Modeling Lab

Simulations using GADGET-2 and OpenFOAM

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Computer-Aided Modeling Lab,
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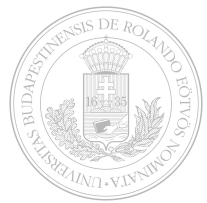


Projects and goals

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

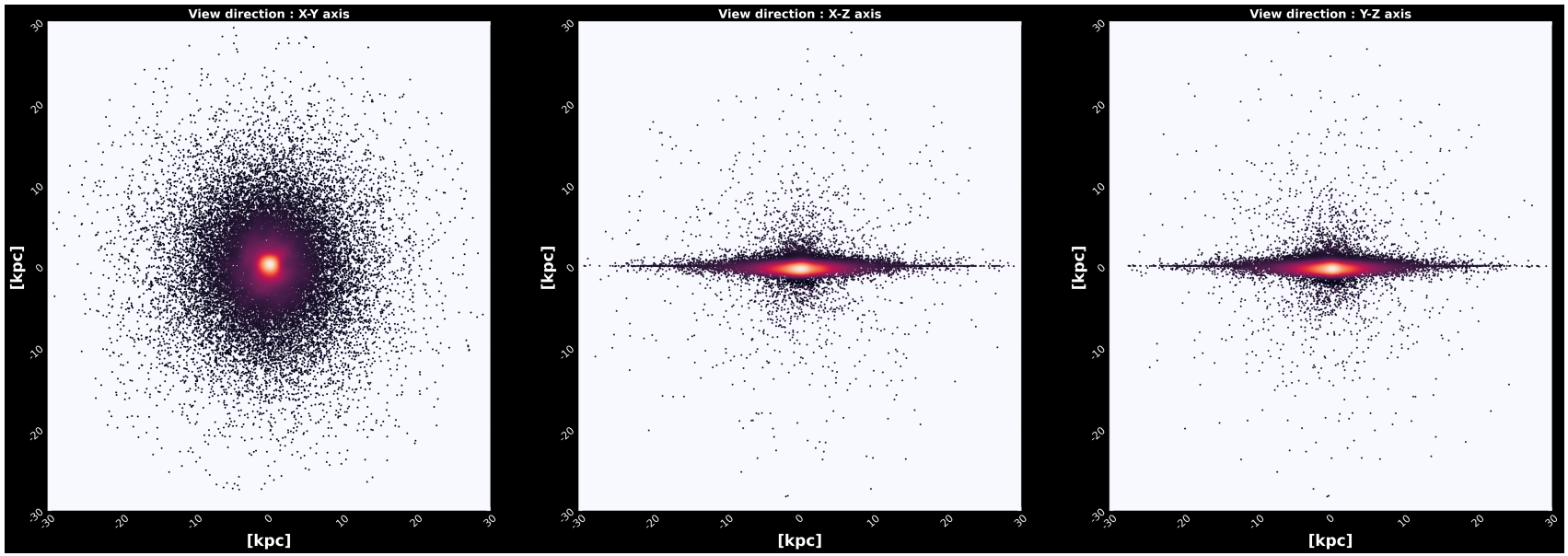


Figure 1: Initial conditions of my rotating galaxy simulation, where only those particles are shown, which are part of the bulge, gas or disk parts of the galaxy. The particles of the halo are hidden here.

Projects and goals

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

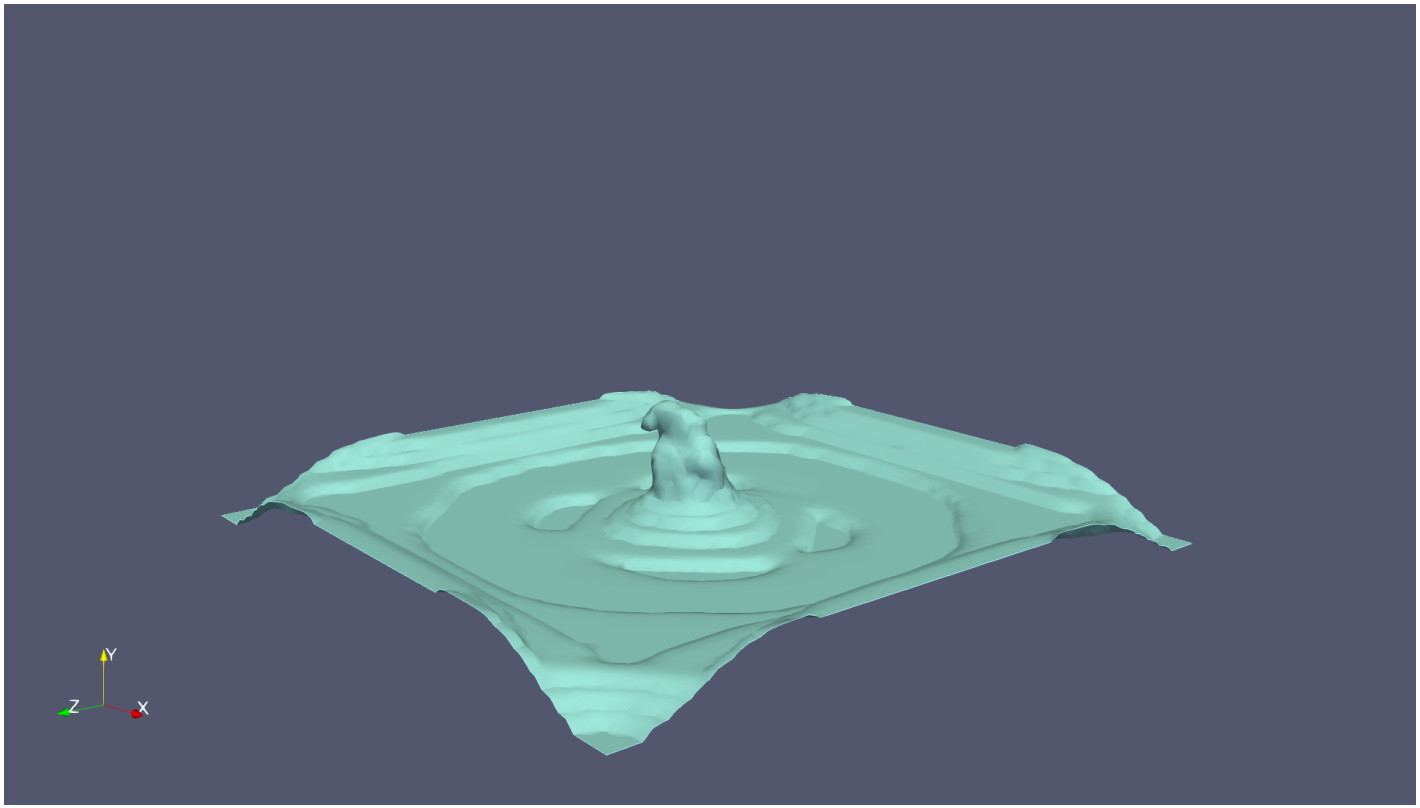
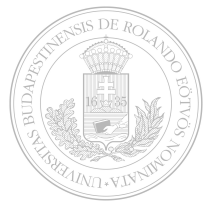


Figure 2: A snapshot from the water droplet simulation, after the droplet hit the surface of the water. The borders of the vessel are rendered invisible.

Project I. – GADGET-2 – Initial problems

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



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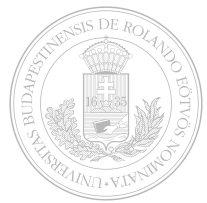
   - Numerous legacy prerequisites
   - Compatibility problems or unnecessarily complicated build process on eg. Windows
   - Initial conditions (ICs) and myriads of simulation parameters need to be set carefully



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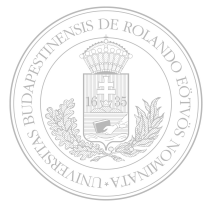

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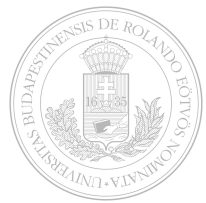
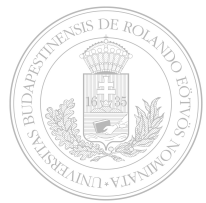
2. IC generation and encoding should be made entirely manually, there is no such thing as an "easy editing tool" (like OpenFOAM does `blockMesh` and others)
3. Requires parallel computation even for "easier" problems



Project I. – GADGET-2 – Project description

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)



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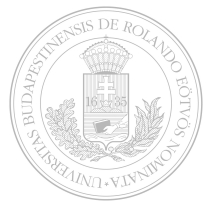
- Simulate a single, isolated, rotating galaxy and measure its rotation curve
- Consider two cases: first where there is is no halo, and second where there is (associate dark matter with the halo of the galaxy)

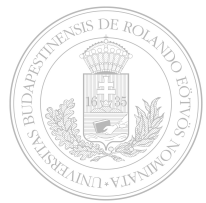
Expectations

- 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



Project I. – GADGET-2 – Results

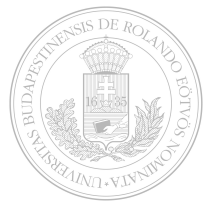
- Created two animations using both of the simulated cases
  1. Link to anim. /w dark matter: `https://youtu.be/fQ1-mvBPwlo`
  2. Link to anim. /wo dark matter: `https://youtu.be/PglE_3H0rwc`
- Analysed the time evolution of the rotation curve of the case with dark matter included
- The expectations were completely fulfilled in both cases



Project II. – OpenFOAM – Project description

Simulation goals

- Simulate a water droplet falling into a vessel with water at the bottom
- The vessel was rectangular in my simulation



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- Simulate a water droplet falling into a vessel with water at the bottom
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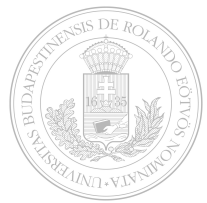
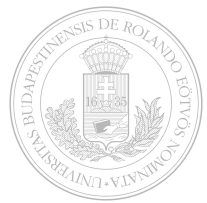
Expectations

1. When the droplet hits the surface of the water it first creates a small hollow in the surface
2. Very soon, the surface tension pulls the pushed away water back, which collides in the middle by force and creates a "column" of water in the middle, growing upwards.
3. The formation of a "corona" could occur along the side of the hollow
4. After all of these, the water continues to wave around in the vessel



Project II. – OpenFOAM – Results

- Create two animations of the water droplet, one side-view, and another top-view shot
  1. Link to side-view shot: `https://youtu.be/OHyLuwYBTWo`
  2. Link to top-view shot: `https://youtu.be/NVMS-t9X5Wg`



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- The expectations were not completely fulfilled, I couldn't observe the formation of a corona, or the shattering of the water column
- However the formation of the hollow after the droplet falling into the water and the water column itself was observed. Also the oscillation of the water in the vessel could be well seen too.