Results of the N-body simulations

Introduction:

In the following simulation the Time reversibility of a Newtonian N body system was investigated. For the simulation used the leapfrog integrator was used.

The following setup was considered for the simulations:

Two particle systems that are randomly distributed in a cube with length r. (Blue and Red). Each system has n particles.

The Two particle systems are slightly separated (i.e. one system was shifted to -x and one was shifted to x (however this was/ is a parameter in the code that can be adjusted)). This was chosen such that the reversibility can be easily observed.

In addition a seed was fixed in the creation of the particle systems to still be able to ensure randomness but also reproducibility.

For the following simulation the concrete parameters where set as:

Radius of the cube: 6*(10**12)

Mass of a single particle: 2*(10**26)
velocity: (-5,0,0) (for right shifted system) (5,0,0) (for left shifted system)

Amount of particles: 13 each system: total 26

Shifting of the center of the system: left: -6.5*10**12 , right: 6.5*10**12
Seed of the right hand side system: 80

Seed of the left hand side system:: 90

Duration of simulation: 6.92*10**10

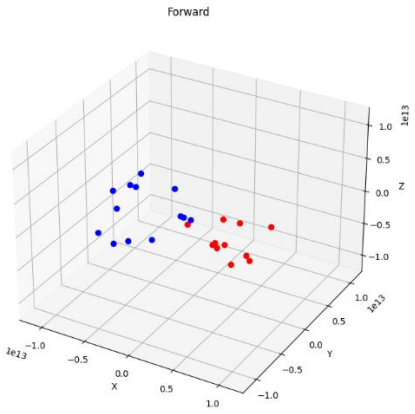
Step of simulation: 350000

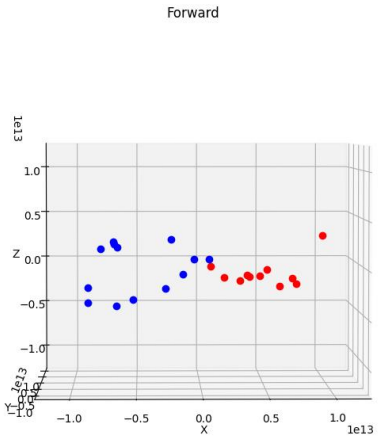
Total amount of steps each simulation: 197715

Constant that ensures that Potential does not rise to infinity: 1000000

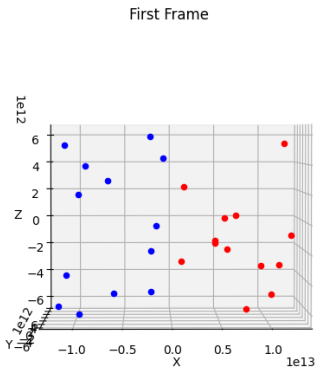
Results:

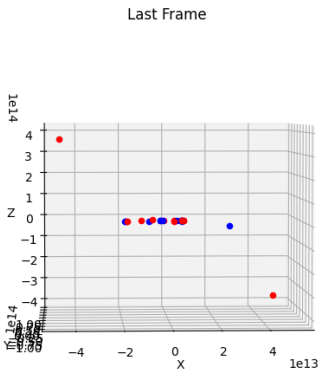
For the start of the simulation we have:



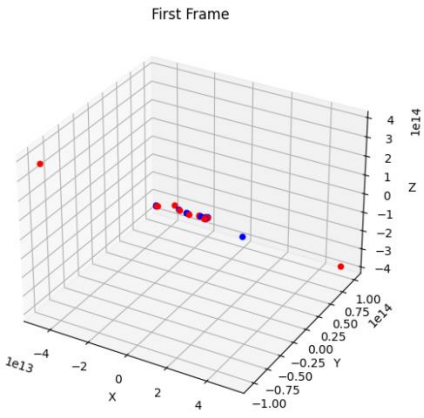


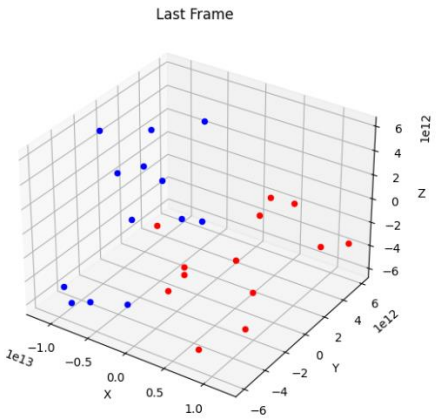
This marks the start of the simulation forward in time. Where the first frame and last frame of the simulation is given by:

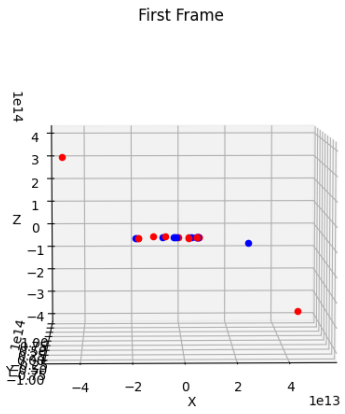


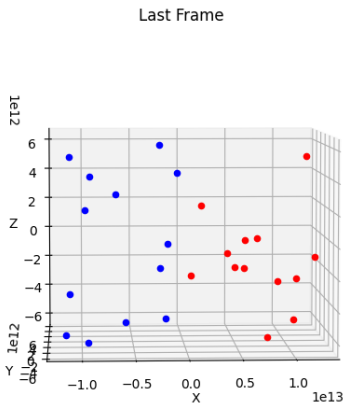


Then without changing the system, the simulation was reversed in time, which got us the following last and first frame



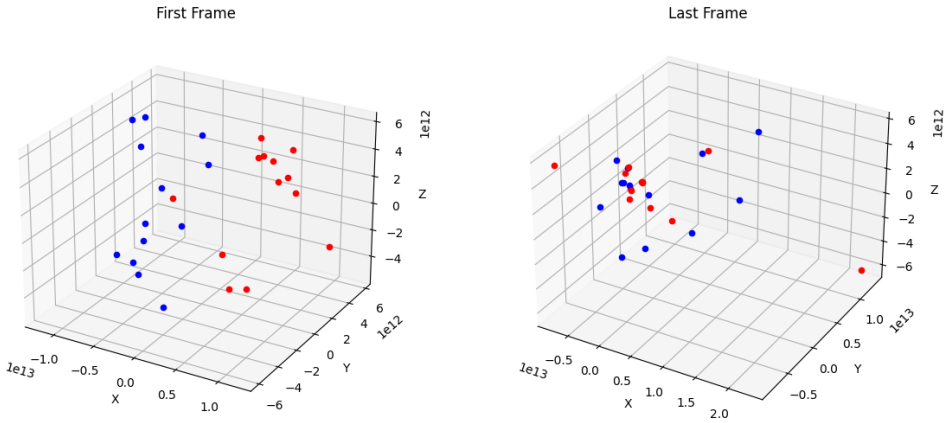




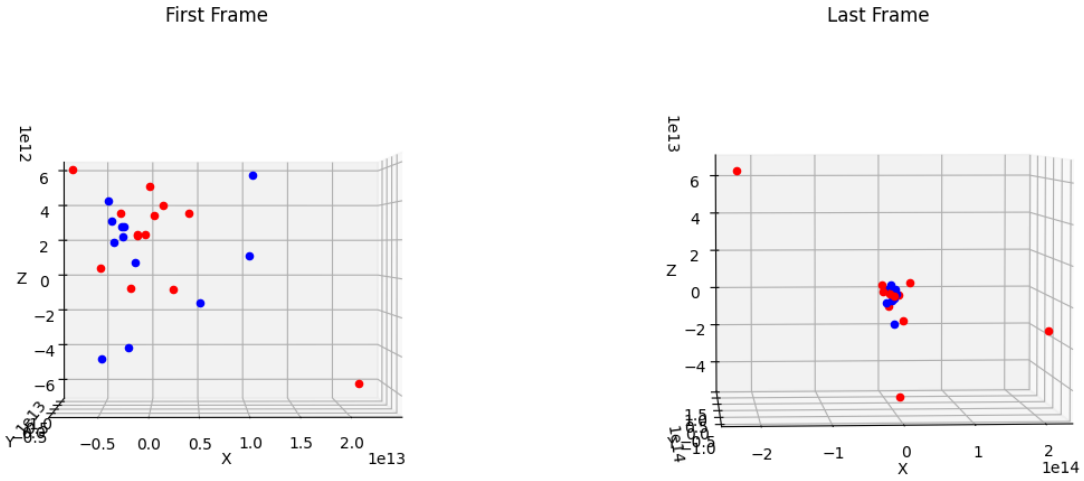


As seen by the images it is possible to reverse the simulation.

Now we consider the simulation where after the forward simulation we remove a particle (in this case particle number 13, which corresponds to a particle of the red system). The forward part of this simulation is identical to the the forward simulation of the previous part:



Now after removing the particle and the simulation backwards one gets:



One can clearly see that the backward simulation does not yield the separation of the particle systems. We could thus in this simulation show that the Newtons Laws are time irreversible when making perturbations.