Simulating Ultra Compact Dwarf Galaxies with the Astronomical Multipurpose Software Environment

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Listing 1. Main routine for solving the gravity of an N-body problem

0.1 Solving the Gravity

A simplest possible script to integrate Newton's equations of motion is given in List. 1. This script starts by including the required AMUSE package `lab` and the python option parser.

[redacted]

The `amuse.lab` directly includes the most usual n-body codes like `Hermite`, `Huayno`, `Mercury`, `BHTree`, `PhiGRAPE` and `Bonsai`.

In listing 2 we present the start a typical program, with a comman line interface and the main calling routines.

The combination of sistings. 1 and 2 together with including the AMUSE package makes for a complete program that may be run and used for further experimentation.

[redacted]

Listing 2. command line options and main calling sequence

Assignment 1 run the script and measure the time it takes to run 2, 4, 8, 16, 32, 65, 128, 256, 512 and 1024 bodies for 1 Myr. Also measure the energy error as a function of N

You can visualize you results by running the plotting script `plot_cluster.py`

Assignment 2 Consider how the computer time scales with N, and if you are happy with the results. Also investigate the error in the energy. Is the energy error sufficient for your objected research project? Can you release the energy error, or does your calculation have better energy conservation?

Assignment 3 So far you have been running with a 4th order Hermite predictor-corrrector N-body integraotr. This is only one of the many N-body integrators in AMUSE. Change the

[redacted]

Listing 3. The integrator call.

[redacted]

Listing 4. Making the bodies

[redacted]

Listing 5. Making bodies with a mass function

integrator to a Barnes-Hut tree code, by replacing the Hermite integroator by the BHTree interator.

The call to the integrator looks like this:

Now redo the analysis from assignment 2.

0.2 Adding a mass function

All stars in your simulation had the same mass, so far. This is not terribly realistic. In the following listing you can see how to introduce a mass function to your N-body system.

There is one caveate here. We have now coupled the stellar masses to the dynamical model, which means that you have lost the freedome to chose an arbitrary total mass of your cluster. Of course, we can easily correct for this, but let's continue with realistic, but somewhat smaller cluster. You could run with more particles (maybe a few 10 millions), but than you probably want to buy a parallel computer and/or a GPU and run with a more optimized code, like `Bonsai`. This code will probably not run on your laptop, but if you have access to `Titan` or `LGM` you should surely try it out.

Assignment 4 Replace the snippet from listing 4 by listing 5, debug and and run the code again.

0.3 Orbit in the Galaxy

Now we are going to add the Galaxy as a simple background potential. The code we use to do this

[redacted]

Listing 6. axi-symmetric model of the galaxy potential.