PHY480 REPORT

1. Abstract

2. Introduction

3. Body

3.1 Literature review

3.1.1 NBODY problem

Newton’s law of gravitation describes how a group of stars interact in a star cluster. These gravitational interactions cause the dynamical properties (velocity, position, acceleration) of the stars to change. This causes a change in the dynamical properties of the whole region. The evolution of this stellar region can be observed in a NBODY simulation. The NBODY problem is incorporates the prediction of future dynamical properties of the stars in the system. The initial properties of the particles in the system are known. In a system of N particles, the acceleration of a particle can be defined as,

-1

Where, mass of the test particle

the unit vector along the direction of the distance vector

the modulus square of the distance between the bodies considered

Integrating equation (1) provides the position and velocity of a particle at any time t. For *N*=2 the above equation is analytically solvable. Since we are considering stellar clusters as our system, where N2, numerical methods are considered.

Numerical integration of equation 1 provides the below solutions.

Where, and the new position and velocity of the particles.

and the initial position and velocity of the particles

, , , the initial acceleration of the particles with the latter three being the 1st, 2nd, 3rd time derivatives.

timestep for the simulation

The timestep *dt* determines the accuracy of the values of the future position and velocity of the particles. It goes inversely with the computational time. There is a rise in the number of calculations done in a single simulation as *dt* drops.

Accuracy in predicting the motion of stars in the cluster is the main task. The error in the solution is proportional to the timestep. As we go to higher orders, a small drop in *dt* will imply a large reduction in the error.

For our project we consider the 2nd order method, with the 4th order predictor-corrector (Hermite scheme) method used in semester 2.

The 4th order predictor-corrector method improves on the accuracy of the previous methods.

3.1.2 History of NBODY simulation

3.1.3 Astrophysics applications of NBODY method

3.2 Progress (WRITE ABOUT PROGRESS)

The initial work on the project was carried by constructing a simple second order code.

3.3 Project plan

At the start of week 1, the core part of the work in semester 2 begins with task1, i.e., building a basic fourth order predictor-corrector code. A time of 2-3 weeks is given for this task based on its difficulty. After forming the base, we require an adaptive timestep for the code (task 2). Depending on the errors obtained from the energy checks, the code either doubles or halves the timestep, *dt*. A similar amount of time of 3 weeks is assigned to this task. The two main components of the code are ready. This leads to task 3 of testing the code. The results obtained from these tests determine whether the code is working. For example, we should observe milankovic cycles when we produce the plot of the orbits of the planets in our Solar System.

Task 4 provides the motivation of writing this piece of code. We apply this code to any astrophysics problem (like late oligarchic phase of planet formation). Moreover, certain tweaks are added at this point to increase the speed of the code. With a time of 2 weeks, it overlaps with the easter break. Then we lead to the most important task 5, the write-up of the report. All the figures and results produced in tasks 3 and 4 are included in the report. Tasks 4 and 5 overlap at the beginning of easter break. A time of 3-4 weeks is assigned so that a draft of the final report can be submitted to the supervisor approximately two weeks before the deadline (17/05/2019). The final task involves in refining the report. Within a week the report is checked for any mistakes before the final submission.

4. Conclusion