Project Proposal

PHYS349 - Advanced Computational Physics

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Numerical analysis of the n-body gravitational problem

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As part of our advanced computational physics course's term project, we would like to explore the subject of n-body gravitational systems. Specifically, we are interested in creating animations and strong visual presentations, and feel this would be a great opportunity to learn and apply.

In this project, we want to create a model that allows for evaluating the movement of large particle systems affected solely by gravity. Our model would offer several integration methods (leapfrog, rk4, verlet, or odeint) and would be adapted for any amount of particles. We will implement the algorithm using NumPy, Scipy, Matplotlib library for efficient numerical calculations and possibly Tkinter (interactive GUI) to stimulate and visualize the motion of celestial objects. We would like to write code that allows for the automatic creation of animations based on integrated results. In addition, a challenge we could give to ourselves would be to create a user interface where a user can easily input coordinates of particles, or select from pre-made scenarios.

In terms of testing, we plan to use automated assertion-based unit tests to verify our algorithm as well as pitting our model against available models online.

We will use our model to investigate the following study cases:

- **Lagrange points**: create a "Sun-Earth" system and show that Lagrange points are stable within our model, as happens in reality.
- **Galaxy collision**: simulate the collision of two galaxies on a parabolic (zero energy) orbit with respect to each other
- **3-body scattering**: simulate interaction of a 3rd star on a binary-star system and evaluate their position as time grows.