

N -body Simulation of Colliding Galaxies

Gregory Beauregard

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Department of Physics
New York University

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Problem Description

- Make a code for N -body Newtonian simulation of colliding galaxies
- Final ICs consisted of two galaxies of 2020 particles each colliding at 45 degree offset
 - Galaxies each contained a supermassive black hole at their center that was 1% of the total galaxy mass
- Major Problems:
 - Accuracy over long timescales
 - Support 1000+ particles
 - Visualization

Accuracy

- Use a symplectic ODE solver, like Verlet
 - Chose a fourth order symplectic solver to implement
- Rerun HW 5 simulation to verify code

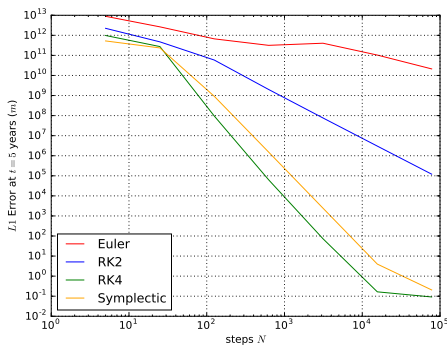


Figure 1: L_1 error as function of steps

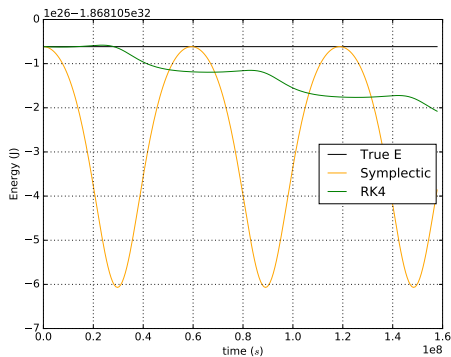


Figure 2: Total energy over time

- Need to support 1000+ particles
- Performance bottleneck: force between each particle
- How to calculate force between every particle?
 - ✗ Loop over them in Python
 - This supported at most 50 particles, took half a day to run small timescale
 - ✓ Use `numpy` to eliminate loops entirely by doing all operations on `numpy` arrays
- Use multi-threaded libraries to rewrite `numpy` code to be parallel
- Final performance: Simulation of collision runs with 2020 particles in about an hour

Visualization and Conclusion

- Data visualization was done in `matplotlib`
- Animated the collision and rendered to video
- Animation is on [▶ YouTube](#)

Questions?