N-Body Simulations with REBOUND

Lab course protocol

Group 3+10

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Abstract

This is optional, but never longer than half a page.

Contents

1 Introduction

Very short summary what the experiment is about and why the subject plays a role in astronomy/astrophysics.

2 Theory

2.1 Classical N-Body Problem

2.2 Time Integrators

2.2.1 Leapfrog

2.2.2 IAS15

2.2.3 WHFast

2.2.4 Gragg-Bulirsch-Stoer

2.3 REBOUND

3 Experiment

3.1 Two Body Problem

We use the simple two body problem to test various integrators in REBOUND (Leapfrog, IAS15, WHFast, Gragg-Bulirsch-Stoer) and compare the quality of the resulting outputs. We also test the quality of the results as we change the timestep from 1 to 10^{-6}
In a two body problem we simulate a moon orbiting a planet, or a planet orbiting a star. The energy and the angular momentum of the system will

remain constant. They are given as:

$$E = -\mu \frac{GM}{2a} \tag{1}$$

$$L = \mu \sqrt{GMa(1-e^2)} \tag{2}$$

Where $\mu = \frac{m_1 m_2}{M}$ is the reduced mass of the system and $M = m_1 + m_2$ is the total mass.
From the above equations we can derive that the semi major axis and the eccentricity of the system should also remain constant when we simulate the system.

3.2 Three Body Problem and Stability of the Planet System

3.3 Jupiter and Kirkwood Gaps

3.4 Resonant Capture of a Planet

4 Conclusions

An important section in which you should critically review the experiment and its results. Mention also parts that did not work out as expected, but keep a neutral to positive view. This can span from a few sentences to half a page.

References

[1] Brown B, Aaron M (2001) The politics of nature. In: Smith J (ed) The rise of modern genomics, 3rd edn. Wiley, New York, p 234–295

[2] Dod J (1999) Effective Substances. In: The dictionary of substances and their effects. Royal Society of Chemistry. Available via DIALOG. http://www.rsc.org/dose/title of subordinate document. Cited 15 Jan 1999

[3] Slifka MK, Whitton JL (2000) Clinical implications of dysregulated cytokine production. J Mol Med, doi: 10.1007/s001090000086

[4] Smith J, Jones M Jr, Houghton L et al (1999) Future of health insurance. N Engl J Med 965:325–329

[5] South J, Blass B (2001) The future of modern genomics. Blackwell, London

Appendix

Code

Please attach here your original handwritten notes and other documents created during the experiment.