Open Internship in the ESA Advanced Concepts Team in 2017

on

Astrophysical Parameter Determination using Chaotic Orbital Regions

Stage topic description

Placing satellites in orbit around celestial bodies is used to examine their properties, particularly for measuring the obliqueness of asteroids and comets. By using chaotic orbits you can find out about characteristics of the orbit faster than the standard gaussian scaling of $\sigma = N^{-1/2}$. Previous research [1] was mostly focused on the determination of the orbit for later times, but this behaviour would be very useful to characterise the properties of celestial bodies. Prof Andrea Milani has shown [4] the scaling one could achieve is $\sigma = N^{-1}$, but in [2] shows in some systems the scaling can reach $\sigma = N^{-2}$.

With the advent of the use of CubeSats for scientific missions, this method of examining celestial bodies could become cheaper in future. This method works best in systems with a short chaotic time period, such as orbits of moons and asteroids. The stagiaire will build a simulation of a chaotic orbital situation, starting with the three body problem. They will then build simulations to calculate the parameters based on various initial conditions. The program will then be tested by seeing if deterministic and chaotic orbits produce gaussian and non-gaussian scaling respectively.

The simulation will then be extended to different orbital situations, with the intent to find which orbital systems this methods of estimation would be best used for.

Candidate's tasks

- Make a simulation of an orbital system with chaotic behaviour.
- Build a program to estimate parameters of an orbital system from satellite position data: test the program on (non-)chaotic orbits and find (non-)gaussian scaling.
- Determine which chaotic systems would be best to achieve better than gaussian scaling.
- Probe phase space of initial conditions to find the best scaling for a given situation.

The ideal candidate

Mandatory:

- Knowledge of dynamical systems
- Experience with numerical methods
- Programming skills (Python, C, C++)

Desirable:

- Knowledge of chaos theory
- Interest in applied mathematics and/or computational physics

- Knowledge of celestial mechanics
- Experience with GPU programming
- Knowledge of numerical optimisation

References

1. The talk by Prof Andrea Milani
2. Parameter Estimation in Chaotic Systems *Elmer S.Hung*
3. Efficient parameter estimation for a highly chaotic system *J. D. Annan, & J. C. Hargreaves*
4. Shadowing Lemma and Chaotic Orbit Determination *Federica Spoto, Andrea Milani*
5. Chaos In The Three-Body Problem *Rick Moeckel*
6. Chaos in Planar, Circular, Restricted Three-Body Problem *Jan Vrbik*