Title: Simulation of multi-body interactions with dynamic hierarchy

MSIAM, Master of Science in Industrial and Applied Mathematics
Master Thesis Proposal 2018-2019
Research project

Funding: LJK
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Internship gratuity: ~550 Euros / month

Description
Gravitational multi-body systems are inherently chaotic. An accurate integration of such systems over long time spans is therefore in principle not possible. However, in practical applications it is often not the exact trajectories, but derived properties such as stability or the evolution of statistical quantities which are of interest. Classical integration methods such as Runge-Kutta perform badly in corresponding simulations, because even conserved quantities such as total momentum or total energy tend to drift away from their initial values. Therefore symplectic integrators are employed, whose algorithms use hierarchies present in the system and perform a corresponding splitting of the Hamiltonian [1]. In some applications, however, the hierarchy is itself part of the dynamics and changes with time. The **objective** of the internship is to develop a symplectic integrator which takes into account the evolution of the hierarchy.
The master student will assist in the development of the algorithms and codes of the symplectic integrator. The work can be based on previous software developments at LJK whose aim was to simulate open star clusters [2].

PhD thesis
The integrator is intended to assist orbital fitting of directly imaged exoplanetary systems by testing the stability of the system. The data of the images, obtained from the VLT telescope in Chile, are combined with data on the proper movement of the host stars from the Gaia satellite and complemented with the stability information to infer the dynamics and orbital parameters of the exoplanetary systems. This next step may be the subject of a PhD thesis within the framework of the newly submitted ANR project Archeops (Architecture of directly observed planetary systems).

References

[1] Beust H. (2003). Symplectic integration of hierarchical stellar systems. *Astronomy and Astrophysics* **400**, 1129-1144.
[2] Despréaux S., Hildebrand R., Maignan A. (2012). Graph Algorithm for the Simulation of the Interaction between Particles. *ICNAAM Conference*, Kos, Greece; AIP Conf. Proc. **1479**, 678-681.