Title: Simulation of multi-body interactions with dynamic hierarchy

MSIAM, Master of Science in Industrial and Applied Mathematics
Master Thesis Proposal 2019-2020
Research project

Funding: LJK
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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. A symplectic integrator with dynamic hierarchy is being developed at LJK. The **objective** of the internship is to further develop the integrator, in particular, to augment it with a module computing the evolution of binary subsystems by using an analytic formula derived from Kepler's laws, and to test it on models of open star clusters.

Prerequisites
basic knowledge in numerical integration, dynamical systems, ordinary differential equations, programming skills

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.