Title: “Tidal evolution of dwarf galaxies in cosmological simulations”

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Abstract:

This thesis contains the description of three different numerical codes used for different aspects of planetary and exoplanetary science. All three codes are running on Graphics Processing Units (GPUs) and make use of their high capability to parallelize numerical operations. The first code (GENGA) is an N-body integrator used for simulating the late stage of terrestrial planet formation and the long term evolution of planetary systems. The late stage of planet formation begins with a number of kilometer sized objects - called planetesimals - that are orbiting around a central star and attracting each other due to mutual gravitational interactions. Collisions between these planetesimals are leading to the formation of more massive planetary embryos and finally to terrestrial planets. The numerical challenge is to compute all mutual interactions as fast as possible and to calculate the orbits of the bodies accurately enough over millions of years without a significant error in the total energy and angular momentum that would cause strong deviations in the bodies orbits.
The first paper in this thesis contains both, a detailed description of the code and its implementation on GPUs, as well as a comparison to other codes.
In the second paper, GENGA is used to simulate the long term stability of exoplanetary systems, containing additional hypothetical super-Earths in between of the detected exoplanets. As a result we found that in many known exoplanetary systems, additional super-Earths, ten times as massive as the Earth, can survive easily for 10 Myr without disturbing the orbits of the other planets too much.
The third paper describes a numerical improvement of the integration scheme of GENGA, which is more accurate and reduces the error in the total energy of about a factor of ten. The improved scheme uses a new criterion to switch between a symplectic and a direct N-body integrator in close encounter phases.
The second code (HELIOS-K) is a opacity calculator used for radiative transfer in planetary atmospheres. It calculates the Voigt line profile for thousands to millions spectral lines, listed in the HITRAN and HITEMP databases. These Voigt profiles are used to compute the opacity function and the transmission function of a molecule, depending on the wavelength, temperature and pressure.
The fourth paper gives a description of the used methods and describes the effects of different resolutions and cutting lengths of the line profiles.
Finally, the third code (THOR-polaris) is a General Circulation Model (GSM) core, which solves the dynamics of a planetary atmosphere. It solves the three dimensional Euler equations with a finite volume scheme on a modified Yin-Yang grid.