Development of N-body Simulation Code for Planetary System Formation With Particle-Particle Particle-Tree Scheme

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In general, the planetary system is thought to be formed from protoplanetary disks surrounding the central star. In particular, it is accepted that terrestrial planets and the cores of gas giant planets are formed by accretion of km size objects (planetesimals) in the protoplanetary disk. The accretion process of the planets has been mainly discussed using the gravitational multi-body simulations (N-body simulations) of planetesimal systems. Various unresolved problems have been pointed out in the conventional standard planetary system formation theory.In recent years, new planetary system formation models have been proposed to solve these problems.However, there is no model with no problem even in these new models. Since N-body simulations with sufficient number of particles has not been performed, the generalized planetary system formation theory has not been constructed yet.

We have developed a new N-body simulation code with particle-particle particle-tree (P^3T) scheme for planetary system formation, GPLUM. The code GPLUM uses a fourth-order Hermite scheme to calculate gravitational interactions between particles within a cut-off radius and a Barnes-Hut tree scheme for gravitational interactions from particles beyond. The conventional simulation codes with P^3T scheme has the bottleneck that the calculation speed decreases when the mass ratio among the particles becomes large. We have solved it by implementing an algorithm which determines the cut-off radius based on mass and orbital semi-major axis of particles individually for each particle. The performance of GPLUM is significantly improved for the simulations of particle systems with mass distribution.

By improving the performance of the N-body simulation code, we made it possible to carry out numerous global simulation with various parameters. GPLUM allows us to perform N-body simulations with ~10^6-10^7 particles. By using GPLUM, we will perform N-body simulations with wide range and high resolution and investigate various parameters by perform parameter studies with N-body simulations.

Keywords: N-body simulation, planetary system formation