国立天文台天文シミュレーションプロジェクト 成果報告書

原始惑星系形成の大規模シミュレーション

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In the standard theory of the formation of planets in our Solar System, terrestrial planets and the cores of gas giant planets are formed through accretion of km size objects (planetesimals) in the protoplanetary disk. The accretion process of the planets has been mainly investigated using N-body simulations. The gravitational N-body simulations of planetesimal systems is the most direct way to calculate the evolution of the accretion process. However, the use of N-body simulations has been limited to idealized model (e.g., perfect accretion) and/or narrow radial range, due to the limited number of particles available. We have developed a new N-body simulation code with particle-particle particle-tree (P3T) scheme for planetary system formation, GPLUM. GPLUM uses a fourth-order Hermite scheme to calculate gravitational interactions between particles within cut-off radii of individual particles and a Barnes-Hut tree scheme for gravitational interactions with particles outside the cut-off radii. In existing implementations of the P3T schemes, the same cut-off radius is used for all particles. Thus, when the range of the mass of the planetesimals becomes large, the calculation speed decreases. We have solved this problem by allowing each particle to determine its appropriate cutoff radius depending on its mass and distance from the central star and thus achieved a significant speedup when the range of the masses of particles is wide.

We have also improved the scalability of the code, and have achieved good strong-scaling performance for up to 1,024 cores in the case of $N = 10^6$.