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Development of a hybrid N body simulation code for planet formation process that can handle number of large particles

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In the present planet formation theory, it is believed that planetesimals evolve to protoplanets through mutual collisions. N body simulation has been used for the study of this process, and the formation mechanisms such as the runaway growth and the oligarchic growth (Kokubo & Ida 1998, 2000) have been found. However, in previous studies the number of particles have been limited to around 10^4, and therefore minimum particle mass used was around 10^{23}g. Moreover, because there is a limitation in the number of particles that can be handled, in almost all N body simulations the assumption of perfect accretion has been used. This assumption is not appropriate for the process of the planet growth in the late stage. Therefore, we developed a new simulation code that can handle large number of particles, to solve these problems.

In N-body simulations, the calculation cost increases as the second power of the number of particles. Moreover, in planet formation simulations, since the formation time is far longer than the orbital timescale of planetesimals, very long calculation is necessary. Because of these reasons high speed simulation algorithm for the planet formation process is needed. Recently, BRIDGE scheme for the globular cluster has been developed (Fujii et al. 2007). This is the code that calculates at high speed while keeping accuracy, using the 4th-order Hermite method for the part where accuracy is necessary, and using the tree method for other parts. Another similar algorithm is the modified SyMBA (Levison & Duncan 2000). This is the high speed integration method which keeps accuracy by splitting the Hamiltonian into two or more parts. We describe a new scheme which combines the strong points of these schemes. We use the method that calculates the near-neighbour forces using the 4th-order Hermite method and the distant forces by the tree method.