The Validity of the Super-Particle Approximation during Planetesimal Formation

Hanno Rein, Geoffroy Lesur, Zoe M. Leinhardt

(Submitted on 31 Dec 2009 (v1), last revised 8 Jan 2010 (this version, v2))

The formation mechanism of planetesimals in protoplanetary discs is hotly debated. Currently, the favoured model involves the accumulation of meter-sized objects within a turbulent disc, followed by a phase of gravitational instability. At best one can simulate a few million particles numerically as opposed to the several trillion meter-sized particles expected in a real protoplanetary disc. Therefore, single particles are often used as super-particles to represent a distribution of many smaller particles. It is assumed that small scale phenomena do not play a role and particle collisions are not modeled. The super-particle approximation can only be valid in a collisionless or strongly collisional system, however, in many recent numerical simulations this is not the case.

In this work we present new results from numerical simulations of planetesimal formation via gravitational instability. A scaled system is studied that does not require the use of super-particles. We find that the scaled particles can be used to model the initial phases of clumping if the properties of the scaled particles are chosen such that all important timescales in the system are equivalent to what is expected in a real protoplanetary disc. Constraints are given for the number of particles needed in order to achieve numerical convergence.

We compare this new method to the standard super-particle approach. We find that the super-particle approach produces unreliable results that depend on artifacts such as the gravitational softening in both the requirement for gravitational collapse and the resulting clump statistics. Our results show that short range interactions (collisions) have to be modelled properly.

Comments:	10 pages, 7 figures, accepted for publication in Astronomy and Astrophysics
Subjects:	**Earth and Planetary Astrophysics (astro-ph.EP)**; Galaxy Astrophysics (astro-ph.GA)
DOI:	10.1051/0004-6361/200912870
Cite as:	**arXiv:1001.0109v2 [astro-ph.EP]**

Submission history

From: Hanno Rein [view email]

[v1] Thu, 31 Dec 2009 09:54:40 GMT (2011kb)

[v2] Fri, 8 Jan 2010 14:23:13 GMT (2010kb)