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Simulating global dust coagulation with grain charging

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Growth of dust particles by collisions is the initial step of planet formation. Conventionally, the theory of dust coagulation in protoplanetary disks assumed electrically neutral dust particles, but in reality dust in the disks is likely to be charged given that the disks are ionized by cosmic rays and stellar X-rays. In our previous work (Okuzumi 2009; Okuzumi et al. 2011a,b), we extensively studied the role of grain charging in protoplanetary dust growth, and concluded that dust growth stalls at its early stage because of the excessively large (negative) charges carried by small dust aggregates. We also predicted that this ”charge barrier” could be overcome (albeit on a very long timescale) if dust in the disks is globally transported by radial drift and turbulent diffusion.

The purpose of the present work is to demonstrate the breakthrough of the charge barrier in a global setup. In order to do this, we have developed a new simulation code for global dust coagulation including the effect of grain charging. The new code is based on a previous code for planetesimal formation (Brauer et al. 2008; Okuzumi et al. 2012) but now calculates charging and Coulomb repulsion of dust particles at each location in a disk consistently with the particle size distribution at the same location. To verify the code, we perform some test simulations and compare them with the prediction from our previous theory.

Keywords: dust, charging, planet formation, protoplanetary disk