Steady Dust Concentration and Planetesimal Formation at the Super/Sub-Keplerian Flow Boundary Created by Non-uniform Growth of MRI

Mariko Kato[1]; Masaki Fujimoto[2]; Shigeru Ida[3]

[1] Dept. Earth and Planetary Sci., Tokyo Inst. Tech.; [2] ISAS, JAXA; [3] Dept. of Earth and Planetary Sci., Tokyo Inst. of Tech.

We have performed three-dimensional CIP-MOCCT simulations including particles moving relative to the gas to investigate the dust motion affected by the turbulence generated by Magneto Rotational Instability (MRI) in a proto-planetary disk with nonzero ohmic resistivity.

A proto-planetary disk is formed as the gas and dusts around a proto-star accrete. In the disk the planetesimal proceeds. However, when the size of dust particles (the solid component of the planets to form) grows to 10 cm ˜1 m, the dust particles fall quickly to the central star because of the drag from the disk gas that rotates slower than the dust particles (dust in-fall problem). Be this true, there is no material left in the disk to form planetesimals. For this problem, Johansen et al. (2007) has presented the possibility of planetesimal formation in the turbulence excited by MRI. On the other hand, since a protoplanetary disk is weakly-ionized, linear analyses of MRI show that a region with small vertical magnetic field has a smaller MRI growth rate and vice versa (Gammie, 1996; Sano & Miyama, 1999). We ever have studied the flow patterns produced by the non-uniformly growing MRI by situating a MRI unstable and a MRI stable annulus in the simulation box and found the new quasi-steady state in which the gas rotates faster than the dust particles in some part of the disk. This result has indicated that the particles could not only be prevented from the in-fall but also be concentrated at the outer edge of the gas super-rotating zone substantially. Then we included dusts as particles exchanging the momentum with gas in our past simulation and followed their motion. As a result, particles are concentrated calmly in the quasi-steady state. The pile up of dust density and significant low velocity dispersion of condensed particles would lead to the planetesimal formation via gravitational instability. Additionally, we address the difference in the radial size of unstable or stable region and particle size.