Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS21-P24 会場:コンベンションホール 時間:5 月 20 日 18:15-19:30

原始惑星系円盤ガスのスーパー/サブケプラー境界におけるダストの動径方向の集積について
Radial Accumulation of Dust Boulders at a Boundary between Super/Sub-Keplerian Flow in a Protoplanetary Disk

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In the process of planetesimal formation, spiral-in of dust particles toward the host star is the most serious difficulty. One of the mechanisms to halt the spiral-in is a radial pressure bump in the disk, at which the boundary between local super/sub-Keplerian flow exists. However, according to accumulation of dust particles at the super/sub-Keplerian transition point, the dust frictional force alters the gas density profile (e.g., Kato et al., 2012).

We think that accumulation processes of the dust particles at the pressure bump, which has the similar size with the bump presented by Kato et al. (2009, 2010). We have investigated the time evolution of dust density distributions due to drag force from the protoplanetary disk gas, taking into account backreaction from the
dust particles to the gas consistently with local 1-D and 2-D hybrid simulations. We treat the disk gas as a grid-hydrodynamics and the dust particles as super-particles.

In 1-D simulations, we found that the gas density distribution is seriously deformed as the dust accumulates at pressure bump in the case with backreaction. At once, the dust density distribution is radially expanded around the boundary between super/sub-Keplerian flow. Finally, the dust particles resume the inward drifts,
and their density distribution achieves the gradual peak in the radial direction. Then the maximum dust-to-gas density ratio is unity.

In 2-D simulations, we confirm the driving of streaming instability in the dust dense region formed by the radial pressure bump. Due to the effect of streaming instability turbulence, the maximum dust-to-gas density ratio raises to 5, which is larger than 1-D results. However it is lower than the result of the 2-D or 3-D MHD simulations presented by Kato et al. (2012), which include the effect of inhomogeneous MRI turbulence.

These dust-to-gas density ratios is too small to drive the gravitational instability, which forms the planetesimals quickly, and the pressure bump is not able to maintain the halting of the dust particles. Therefore, we conclude that the halting mechanism of pressure bump is not able to form the planetesimals very well by itself. Then we suggest the possibility that the effect of the maintenance or restoration to the pressure bump might increase the dust density and form the planetesimals via gravitational instability.

キーワード: 微惑星形成, 原始惑星系円盤
Keywords: planetesimal formation, protoplanetary disk