

Shear Instability of the Dust Layer and Behavior of Dust in a Protoplanetary Disk

Naoki Ishitsu[1]; Minoru Sekiya[2]

[1] National Astronomical Observatory ; [2] Earth and Planetary Sci., Kyushu Univ.

A newborn star is surrounded with a protoplanetary disk, which consists of the gas component of the hydrogen and helium, and the dust component of silicate, etc. Planets are expected to be formed in the protoplanetary disk. The planetesimals, which are kilometer-sized bodies, need to be formed before the planetary formation. The model has advocated that dust aggregates settle toward the midplane of the disk, and dust layer formed become the gravitational instability due to the self-gravity. The planetesimals are formed due to the contraction of the dust layer fragmented. However, the dust aggregates can not settle further since the dust aggregates are stirred up if the disk is turbulent. Then the planetesimals cannot be formed due to the gravitational instability. Even if there is no global turbulence in the disk, it has been suggested that the turbulence can arise in the dust layer. Dust tends to move around a central star at the Kepler velocity, balancing the gravitation of the central star and the centrifugal force. On the other hands, the gas trends to move around with sub-Kepler velocity by the pressure gradient. The gas and dust exert the drag force each other, and then their velocity depends on the dust to gas spatial density ratio. Thus shear arises in the dust layer if the dust aggregates settle down. Then the shear instability can occur in the dust layer. If so, there is the possibility that flow transits to turbulent. Turbulence stirs up the dust aggregates from the midplane.

We have performed the linear analysis in order to investigate the stability of the shear flow in the dust layer. We found that the shear instability occurs while the dust aggregates settles toward the midplane. However, it has not yet been confirmed that the flow becomes turbulent due to the non-linear effect after the occurrence of the instability. It is expected that the flow becomes laminar again after the dust aggregates are stirred if the flow is turbulent. Then, it is important to investigate what for the vertical dust density distribution to reach in order to know how the planetesimals are formed. In this work, we perform the numerical simulation of a shear flow in the dust layer. We investigate behavior of dust after transition to turbulence.