Linear analysis of Magneto-Rotational Instability under a charge exchange effect in Dusty Plasmas

Keisuke Shirakawa[1]; Masahiro Hoshino[2]

[1] EPS, Univ. of Tokyo; [2] Earth and Planetary Sci., Univ of Tokyo

Magneto-Rotational Instability (MRI) was first proposed by Velikov and Chandrasekhar in 1950s-60s and rediscovered by Balbus and Hawley in 1991. This instability is believed to generate turbulence in magnetized, differentially rotating accretion disks and can contribute to strong turbulent viscosity within several periods of orbit. Thus, this instability is considered to play a major role in the context of planet formation which requires a strong viscosity effect for a radial transportation of angular momentum and particle itself. This instability is driven by a slow-mode type wave which is split from Alfven wave by Coriolis force effect. Study on MRI is usually performed under MHD approximation and previous studies have shown that several effects such as Ohmic dissipation, Hall currents, and ambipolar diffusion would modify a behaviour of MRI.

On the other hand, effect of dust component is recently studied in space plasma physics. Our space is filled up with plasma which is constituted by about 99% of electrons and ions and about 1% of dusts. These dusts are as massive as 10^6-10^{18} ions and they carry 10^3 negative charges through several atomic processes like collisions with electrons and photoelectric effects. Since charge-to-mass ratio of dusts extremely differs from those of electrons and ions, dust particles are treated as a third component of the plasma in the MHD approximation. Plasma phenomena such as wave propagation and instabilities are often modified by existence of dusts. In addition, previous studies have shown that the effect of time varying dust charges can contribute to a modification of plasma dynamics. So, since Alfven waves can be modified by existence of dust components, so as a behaviour of MRI itself.

In this study, we analysed a set of 3-fluid MHD equations. We assumed plasma is weakly ionized, and electrons are captured by dust particles so that dust particles are the dominant negative charge carriers. We also assumed that charge-to-mass ratio of dust is temporally varying through collisions with ions. We found that the effect of charge exchange would modify the unstable region of MRI. In this presentation, we discuss an effect of dust components on the evolution of MRI.