Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PEM31-01 Room:503 Time:May 1 15:15-15:40

Physics of weakly ionized dusty plasmas in planet formation

OKUZUMI, Satoshi[1*]

[1]Graduate School of Science and Engineering, Tokyo Institute of Technology

Planets form in gas disks around young stars. These protoplanetary disks are a typical example of weakly ionized plasmas in space: they are cool (∼10-1000 K) but are nonthermally ionized by galactic cosmic rays and stellar X-rays. The disks can also viewed as dusty plasmas as they contain micron-size dust particles from which planets form.

In this talk, we highlight interesting aspects of protoplanetary disks as weakly ionized dusty plasmas, and discuss their importance in planet formation as well as the MHD of the disks themselves. In particular, we focus on the interplay between charged dust particles and disk's MHD turbulence. Ionized accretion disks are prone to become turbulent because of the magnetorotational instability (MRI; Balbus & Hawley 1991). In protoplanetary disks, the activity of MRI strongly depends on how much dust has grown to larger solid bodies, as small dust particles determine the ionization degree of the disk gas. Meanwhile, turbulence, if present, drives the relative velocity of solid particles, which in turn affects how far the particles can grow by collisions. We briefly review recent developments in the numerical study of MRI-driven turbulence, and then discuss possible coevolution of MRI turbulence and dust particles as predicted by our latest self-consistent simulation (Okuzumi & Hirose 2012).

We will also highlight the importance of plasma heating by turbulent electric fields. A simple order-of-magnitude estimate shows that electric fields in MRI turbulence can significantly heat up electrons in the gas. This implies that Ohm's law can become *nonlinear* in the field strength. To study the nonlinearity of Ohm's law, we construct a gas-dust charge reaction model that takes into account the heating of ionized gas particles as well as impact ionization by hot electrons (Okuzumi & Inutsuka, in prep.). We find that the heating gives rise to negative differential resistivity at a high electric field strength. This occurs because heated electrons more frequently adsorb onto dust particles. The reduced conductivity will lead to suppressed MHD turbulence. Our ionization balance calculations predict that this effect become important in realistic protoplanetary disks (Mori & Okuzumi, in prep.).

Keywords: weakly ionized plasma, dust, planet formation, MHD, turbulence