Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PPS020-05 Room:103 Time:May 24 09:30-09:45

The calculation of ionization degree in planetary gaseous disks: the effect of charged dust grains

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There are many studies on the ionization degree of the protoplanetary disks, but no one has calculated that of circumplanetary disks with dust grains yet. It is important to understand the structure and evolution of circumplanetary disks, since the mass accretion through the disk onto the central planet is important in the early formation phase of the disks, and in addition, they are the sites of satellite formation. Despite the low temperature, the circumplanetary disks are ionized weakly because of galactic cosmic rays and radionuclides. Resultant ionized particles make secondary ions and molecules, and they are captured by dust grains. Weak ionization of the disk has important consequence for their evolution since the coupling between magnetic field and gas produces turbulence driven by magnetorotational instability. Thus, it is important to investigate the ionization fractions of various particles in the circumplanetary disk.

Inclusion of the effect of dust grains is essential when we calculate the ionization fraction, because the capturing of charged particles by dust grains makes the ionization degree lower. In the circumplanetary disks, dynamical timescales are shorter than that of protoplanetary disks, and timescales of various reactions are even shorter than the dynamical timescale of disks, which suggests the importance of accurate time-dependent calculation of ionization degree in disks. However, it remains difficult to calculate highly time-dependent ionization degree numerically. Okuzumi (2009) has shown that the charge distribution of dust grains can be approximated by a normal distribution. That approximation decreases the number of equations, and makes us calculate the ionized degree more quickly.

In this presentation, I will describe the important ionization processes and our fast method for calculation of charge state distributions of various particles and dust grains.

Keywords: protoplanetary disk, circumplanetary disk, ionization degree, dust grain, magnetorotational instability, numerical simulation