P136-007 **Room: 304** **Time: May 21 16:48-17:00**

The gas temperature in the dissipating solar nebula: Influences on the various processes at the final stage of planetary formation

Akiko Sakamoto[1]; Yutaka Abe[1]

[1] Earth Planetary Sci., Univ. Tokyo

Circumstellar disks are the birthplaces of planetary systems. In these disks, nebula gas dissipates and is lost within the timescale of 10^{6-7} years. However, it is not certain whether or not the nebula gas existed around terrestrial planets at the final stage of planetary formation.

It was shown that if the nebula gas whose density is 10^{-4}-10^{-3} times as much as that in the minimum mass solar nebula (MMSN) model is left around terrestrial planets, their eccentricities are damped due to the tidal interaction with nebula gas (Kominami & Ida, 2002; 2004). In such condition, however, it is possible that the terrestrial planets capture the enormous amounts of the surrounding nebula gas. Mizuno et al. (1980; 1982) showed that if the nebula gas whose density is as much as that in the MMSN model exist around the Earth during its accretion, the amounts of He and Ne captured by the Earth from the surrounding nebula gas are too much more than those exist in the present Earth's atmosphere. Previous studies (Nakazawa et al., 1985; Ikoma & Genda, 2006) showed that even if the density of nebula gas is 10^{-4}-10^{-3} times as much as that in the MMSN model, the amount of nebula gas captured by the Earth is about 10% of that captured in case the density of nebula gas is as much as that in the MMSN model. The amounts of He and Ne captured in this case, i.e., 10% of those calculated by Mizuno et al. (1980; 1982), is still much more than those exist in the present Earth's atmosphere. Therefore, it is considered that the problem of eccentricity damping due to nebula gas is not compatible with that of the rare gas abundances in the Earth.

We aim to reconcile the above problems. For this purpose, we examined the possibility that the gas temperature in a thin solar nebula is much higher than that in the previous estimate. Previous studies (Nakazawa et al., 1985; Ikoma & Genda, 2006) assumed that the gas temperature equals to the dust temperature (about 280K at 1AU) even in case they took into account the decrease in the density of nebula gas due to its dissipation. However, this assumption may not be valid in a thin solar nebula because of less frequent collisions among dust and gas particles due to the decrease in the density of nebula gas. Furthermore, since mutual collisions among gas particles are also less frequent, cooling efficiency of nebula gas would be worse. Therefore, it is expected that the gas temperature in a thin solar nebula is much higher than the dust temperature. Increase in the gas temperature results in increase in the thermal energy of nebula gas compared to the gravitational potential of planets. Thus, it results in order of magnitude decrease of the amount of nebula gas (i.e., He and Ne) captured by the Earth.

On the basis of the above expectation, we calculated the temperature of nebula gas whose density is 10^{-4} times as much as that in the MMSN model. For the heating processes of nebula gas, effects of the photoelectric heating due to the carbonaceous grains and the polycyclic aromatic hydrocarbons (PAHs), cosmic ray and X-ray heating are included. Cooling processes due to the rotational lines of CO, the fine structure and the metastable line of CI, CII, OI are included. Thermal coupling between gas and dust particles is also included.

The results of our calculations indicated that the gas temperature is strongly dependent on the amounts of CO and dust particles, which are both effective coolants of nebula gas. If the volume fraction of CO and the mass fraction of micron-sized dust particles are both lower than 10^{-6}, the temperature of nebula gas is about 1400K at the disk midplane of a heliocentric distance of 1AU. In such condition, the amount of Ne captured by an Earth-sized planet is lower than that in the present Earth's atmosphere. Therefore, it is possible that the problem of eccentricity damping due to nebula gas is reconciled with that of the rare gas abundances in the Earth.