Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PPS24-13 Room:A02 Time:May 27 15:30-15:45

Chemical Reactions in Protoplanetary Disks and Possibility of Detecting H2O Snowline using Spectroscopic Observations

NOTSU, Shota[1*] ; NOMURA, Hideko[2] ; ISHIMOTO, Daiki[1]

[1]Department of Astronomy, Kyoto University, [2]Tokyo Institute of Technology

Inside H_2O snowline in protoplanetary disks, H_2O evaporates from the grain surface into gas. On the other hand, it is frozen out on the grain surface in the cold region beyond H_2O snowline. H_2O snowline is the line that divides the two different regions. H_2O ice enhances the solid material in the cold outer part of a protoplanetary disk, which promotes the formation of cores of gaseous planets. We can also regard H_2O snowline as the dividing line between forming regions of rocky planets and gas giant planets. In the disks around solar-mass T-tauri stars, H_2O snowline is thought to exist at a few AU from the central star. Therefore, it is difficult to detect H_2O snowline of exoplanetary systems by imaging observations, since their spatial resolution is insufficient.

In contrast, H_2O emissions from protoplanetary disks are detected by recent observations of Spitzer and Herschel telescope. Zhang et al. (2013) estimated the position of H_2O snowline by using the intensity ratio of different H_2O lines, but the result depends on the model of temperature distribution in the protoplanetary disk. We consider that H_2O snowline can be detected more directly by analyzing the velocity profiles of H_2O line spectra that will be obtained by high dispersion spectroscopic observations in near future.

We have proposed the method of detecting H_2O snowline by analyzing the velocity profiles of H_2O line spectra that will be obtained by high dispersion spectroscopic observations.

First, we calculate chemical reactions using a self-consistent physical model of protoplanetary disks and investigate abundance distribution of H_2O gas and the position of H_2O snowline. We confirmed that the abundance of H_2O is high not only in the inner region of H_2O snowline near the equatorial plane but also in the hot surface layer of outer disk.

Second, we calculate the velocity profiles of H_2O emission lines from protoplanetary disk, and found that we can obtain the information of H_2O snowline through investigating the profiles of some emission lines that have small Einstein A coefficient and large excitation energy. The wavelengths of the useful H_2O emission lines range from mid-infrared to sub-millimeter.

In addition, we investigate the effect of grain surface reactions and dust size growth.

When we include grain surface reactions in our calculations, the abundance of water vapor increases inside H_2O snowline, while it decreases in the hot surface layer of outer disk. Hence, the line fluxes of H_2O transitions with small Einstein A coefficient and high excitation energy become higher. It appears more significantly in the lines at the wavelengths of infrared than those at sub-millimeter. It is also shown that H_2O lines with large Einstein A coefficient can be used to detect H_2O snowline, since H_2O emission from the hot surface layer of outer disk become small.

On the other hand, when we consider dust size growth, the abundance of water vapor increases in the hot surface layer of outer disk. Therefore, we need to select H_2O transition lines with smaller Einstein A coefficients in order to identify the H_2O snow line from the molecular line profiles.

We also discuss the possibility of future observations range from mid-infrared to sub-millimeter (e.g., ALMA, TMT, SPICA).

Keywords: H2O snowline, protoplanetary disk, calculation of chemical reactions, grain surface reaction, dust size growth, spectroscopic observation