

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

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In the hot inner part of protoplanetary disks, H₂O evaporates from the dust surface into gas. On the other hand, it freezes on the dust surface in the cold outer part of the disks. H₂O snowline is the line which divides the two different regions [1]. H₂O 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 H₂O snowline as the dividing line between forming regions of rocky planets and gas giant planets. In the case of disks around solar-mass T-tauri stars, it is considered that the H₂O snowline exists at a few AU from the central star. Therefore, it is difficult to detect H₂O snowline of exoplanetary systems by imaging observations, since their spacial resolution is insufficient.

In contrast, H₂O emissions from protoplanetary disks are detected by recent observations of Spitzer and Herschel telescope. Zhang et al. (2013) [2] estimated the position of H₂O snowline by using the intensity ratio of different H₂O lines, but the result depends on the model of temperature distribution in the protoplanetary disk. In this work we propose the method of detecting H₂O snowline more directly by analyzing the velocity profiles of H₂O line spectra which will be obtained by high dispersion spectroscopic observations in near future.

First, we calculate chemical reactions using a self-consistent physical model of protoplanetary disks and investigate abundance distribution of H₂O gas and the position of H₂O snowline. As a result we confirmed that the abundance of H₂O is high not only in the inner region of H₂O snowline near the equatorial plane but also in the hot surface layer of outer disk.

Second, we calculate the velocity profiles of H₂O emission lines from protoplanetary disk, and found that we can obtain the information of H₂O snowline through investigating the profiles of some emission lines which have small Einstein A coefficient and large excitation energy. The wavelengths of the useful H₂O emission lines range from mid-infrared to submillimeter. We also discuss the possibility of future observations.

References

- [1] C. Hayashi, 1981, Progress of Theoretical Physics Supplement 70, 35
- [2] K. Zhang, K. M. Pontoppidan, C. Salyk, et al. 2013, ApJ 766, 82
- [3] C. Walsh, T.J. Millar, & H. Nomura, 2010, ApJ 722, 1607