Water lines and multiple ring and gap structures of the protoplanetary disk around HD 163296 observed by ALMA

S. Notsu,[1] E. Akiyama,[2] A. Booth,[3] H. Nomura,[4] C. Walsh,[3] T. Hirota,[5] M. Honda[6], T. Tsukagoshi,[5] T. J. Millar[7]

[1]*Department of Astronomy, Graduate School of Science, Kyoto University, Japan*

[2]*Institute for the Advancement of Higher Education, Hokkaido University, Japan*

[3]*School of Physics and Astronomy, University of Leeds, UK*

[4]*Department of Earth and Planetary Science, Tokyo Institute of Technology, Japan*

[5]*National Astronomical Observatory of Japan, Japan*

[6]*Department of Physics, School of Medicine, Kurume University, Japan*

[7]*School of Mathematics and Physics, Queen's University Belfast, UK*

Observationally locating the position of the H2O snowline in protoplanetary disks is crucial for understanding the planetesimal and planet formation processes, and the origin of water on the Earth. The velocity profiles of emission lines from disks are usually affected by Doppler shift due to Keplerian rotation. Therefore, the line profiles are sensitive to the radial distribution of the line-emitting regions. In our previous works (e.g., [1][2][3]), we calculated the chemical composition of the disks around a T Tauri star and a Herbig Ae star using chemical kinetics, and then the water line profiles to identify that lines with small Einstein A coefficients and relatively high upper state energies are dominated by emission from the hot midplane region inside the H2O snowline, and therefore through analyzing their line profiles the position of the H2O snowline can be located.

We got the upper limit fluxes of ortho-H2(16)O 321 GHz, para-H2(18)O 322 GHz, and HDO 335 GHz lines from the protoplanetary disk around the Herbig Ae star HD 163296, using ALMA [4]. These water lines are considered to be the candidate water lines to locate the position of the H2O snowline, on the basis of our previous model calculations [1][2][3]. We compared the upper limit fluxes with the values obtained by our model calculations with dust emission, and we constrained the H2O snowline position and the dust properties from the observations. Future observations of submillimeter water lines with longer observation time are required to clarify the position of the H2O snowline in the disk midplane.

We also detected multiple ring and gap patterns in the 0.9 mm (ALMA Band 7) dust continuum emission. The 0.9 mm dust continuum emission has an asymmetry in the long axis direction, although previous observation of the 1.3 mm (ALMA Band 6) dust continuum emission did not have it [5].

References

[1] S. Notsu, H. Nomura, D. Ishimoto et al., 2016, ApJ, 827, 113
[2] S. Notsu, H. Nomura, D. Ishimoto et al., 2017, ApJ, 836, 118
[3] S. Notsu, H. Nomura, C. Walsh et al., 2018a, ApJ, 855, 62
[4] S. Notsu et al., 2018b, in prep.
[5] A. Isella, G. Guidi, L. Testi et al., 2016. Phys. Rev. Lett., 117. 251101