HCO^+ and ionization structure observed by ALMA

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We observed HCO^+(J=1−0) and $H^{13}CO^+$ (J=1−0) emission towards the five protoplanetary disks around IM Lup, GM Aur, AS 209, HD 163296, and MWC 480 as part of the MAPS project[1][2]. HCO^+ is detected and mapped at 0.3" resolution in all five disks, while $H^{13}CO^+$ is detected (SNR >6σ) towards GM Aur and HD 163296 and tentatively detected (SNR >3σ) towards the other disks by a matched filter analysis. Inside a radius of R~100 au, the HCO^+ column density is flat or shows a central dip. At outer radii (≳100 au), the HCO^+ column density decreases outwards, while the column density ratio of HCO^+/CO is mostly in the range of ~10^{-5}–10^{-4} . We derived the HCO^+ abundance in the warm CO-rich layer, where HCO^+ is expected to be the dominant molecular ion. At R≳100 au, the HCO^+ abundance is ~ 3×10^{-11}–3×10^{-10} , which is consistent with a template disk model with X-ray ionization. At the smaller radii, the abundance decreases inwards, which indicates that the ionization degree is lower in denser gas, especially inside the CO snow line, where the CO-rich layer is in the midplane. Comparison of template disk models with the column densities of HCO^+, N_2H^+, and N_2D^+ indicates that the midplane ionization rate is ≳10^{-18} s^{-1} for the disks around IM Lup, AS 209, and HD 163296. We also find hints of an increased HCO^+ abundance around the location of dust continuum gaps in AS 209, HD 163296, and MWC 480.

We also plan to show the summary of molecular column densities obtained in MAPS project and some model results for discussions in the poster session.

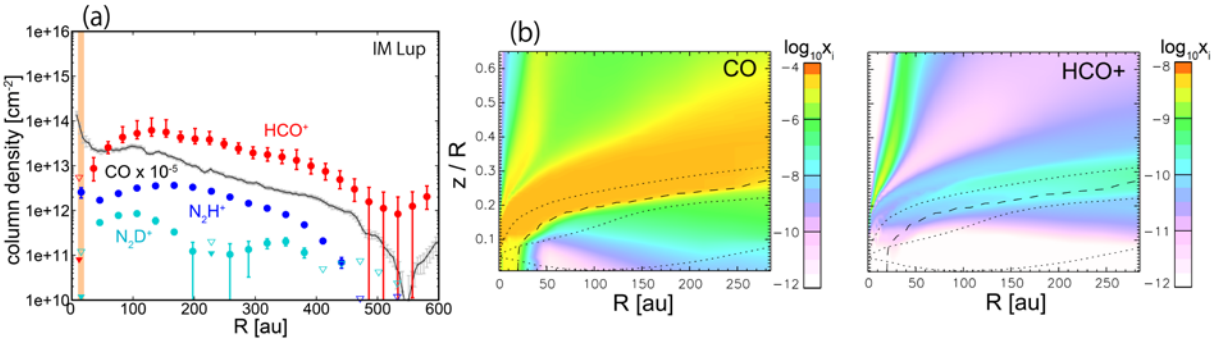

Figure: (a)Radial distributions of column densities of CO, HCO+, N2H+, and N2D+ in IM Lup derived from MAPS project. (b) Distributions of CO and HCO+ in a tempate disk model.

References

[1] Aikawa, Y., Cataldi, G., Yamato, Y. and MAPS team (2021) "Molecules with ALMA at Planet-forming Scales (MAPS) XIII: HCO+ and disk ionization structure", ApJS, in press
[2] Oberg, K.I., Guzman, V.V., Walsh, C., Aikawa, Y., Bergin, E.A. and MAPS team (2021) "Molecules with ALMA at Planet-forming Scales (MAPS) I: Program Overview and Highlights", ApJS in press