

The N_2H^+ ring in Protoplanetary Disks

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We investigate the chemistry of ion molecules in protoplanetary disks, motivated by the detection of N_2H^+ ring around TW Hya[1]. While the observed ring coincides with the CO snow line, it is not apparent why N_2H^+ is abundant outside the CO snow line, because the sublimation temperature of N_2 , the mother molecule of N_2H^+ , is similar to that of CO. We reproduced a ring of N_2H^+ in a disk model with mm grains, but not in a model with ISM dust. In the former, the ring is formed by a combination of the CO sink and photo-reactions, which prevent the N_2 sink. We also derived analytical formulas of molecular ion abundances as functions of density, ionization rate and abundances of major neutral molecules. The formulas are useful in constraining the ionization rate and also abundances of major molecules, such as CO and N_2 , from the observations. Using the analytical formulas, we show that without the CO sink effect, N_2H^+ ring is reproduced only if the sublimation temperature of N_2 is lower than that of CO. We also found that in the model without the sink effect, N_2H^+ exists mostly in the disk midplane, while in the model with CO sink, N_2H^+ is abundant in the layer relocated from the midplane. In the former case, the N_2H^+ abundance would depend also on whether cosmic-ray can reach the disk midplane[2].

References

[1] Qi, C, Oberg, K. I., Wilner, D. J., D'Alessio, P., Bergin, E.A., Andrews, S. M., Blake, G. A., Hogerheijde, M. R., van Dishoeck, E. F. 2013, *Science*, 341, 6146

[2] Aikawa, Y. et al. in prep