JWST OPENS A NEW ERA IN ASTROCHEMISTRY

TAKESHI OKA, *Department of Astronomy and Astrophysics and Department of Chemistry, The Enrico Fermi Institute, University of Chicago, Chicago, IL, USA*.

Historical sketch: Charlie Townes and I are the only two astronomical spectroscopists who switched to infrared after few years of radio astronomy. Townes did atomic spectroscopy and discovered the black hole at the center of the Galaxy.[a] I switched because H_3^+, central in astrochemistry, has spectrum only in the infrared region.

Dense and diffuse clouds: It took us 16 years to observe the spectrum of H_3^+ in dense clouds[b] as theoretically predicted by Herbst and Klemperer and Watson, but had we tried diffuse clouds in the Galactic center we would have had found it withing a few years. Radio (ALMA) astronomy is for emission spectroscopy in dense clouds while infrared (JWST) spectroscopy is for absorption spectroscopy in diffuse clouds.

Molecules of interest: So far astrochemistry has been mostly the science of dense clouds, but JWST will bring in rich chemistry in diffuse clouds. Dense clouds are localized. Diffuse clouds give a bigger picture. Patrick Thaddeus said, "One should not look at an elephant with a magnifying glass". Spectra of the following molecules will be observed: HD, CH, NH, OH, HD^+, CH^+, NH^+, OH^+, H_3^+, H_2D^+, CH_2, NH_2, H_2O, CH_2^+, NH_2^+, H_2O^+. These are kind of molecules observed by Herschel Observatory. Many of them were analyzed as in dense clouds, but they are all in diffuse clouds. Apart from H_3^+ they are all polar molecules with high rotational constants therefore the spectrum is composed of 1 line apart from fine and hyperfine structure. For H_3^+ three rotational levels (J,K) = (1,1), (1,0), and (3,3) levels are populated.

Stars of interest: Absorption spectroscopy needs bright and young stars with a smooth continuum for the radiation source. Ben McCall found 27 stars that are usable to conduct absorption spectroscopy toward the Galactic disk.[c] We found 18 stars toward the Galactic center[d] These stars will be useful for the JWST observation.

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[a] Wollman, E.R., Geballe, T.R., Lacy, J.H., Townes, C.H. 1976, ApJ 205, L5; 1977, ApJ 218, L103

[b] Geballe, T.R., Oka, T. 1996 Nature, 384, 334

[c] Indriolo, N., McCall, B.J. 2012, ApJ 745, 91

[d] Oka, T., Geballe, T., Goto, M., Usuda, T., McCall, B.J., Indriolo, N. 2019, ApJ 883, 54(31pp)