Icy Origin of Complex Molecules in Embedded Protostars

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In recent years, the increasing detection of gas-phase complex organic molecules (COMs) in Class 0/I protostars highlights the extensive chemical evolution at the onset of star and planet formation. Recent ALMA surveys found ~40% protostars without detectable gaseous COMs [1]. It is thus unclear whether most protostars undergo the similar chemical evolution, resulting in formation of COMs. Most COMs are thought to form in the ice mantles covering dust grains. Therefore, constraining the ice composition in embedded protostars would provide the smoking gun evidence to answer the origin of chemical diversity in gas-phase measurements. Ice measurements had been limited by low-resolution and limited sensitivity until JWST, which can probe ices at a spatial scale comparable to that by ALMA with unprecedented sensitivity. In this talk, I will present the results of the CORINOS program, which aims to map the ice distribution toward a sample of protostars chosen to represent ranges of complex chemistry and thermal structure using JWST/MIRI. I will share the ice analysis toward a Class 0 protostar, IRAS 15398-3359 [2], where we detect ice absorption of H2O, CO2, CH3OH, CH4, and NH3 as well as signatures of organic ice, including HCOOH, H2CO, C2H5OH, CH3CHO, CH3COOH, and HCOOCH3. The ice abundance will be compared with the abundance of gas-phase COMs surveyed by ALMA, compiling a complete chemical budget of ice and gas. I will also present preliminary results of the observations of the remaining sources. The data of the CORINOS program show striking details on the ice absorption as well as the protostellar structure, demonstrating the prospect of understanding organic chemical evolution from protostars to planets.

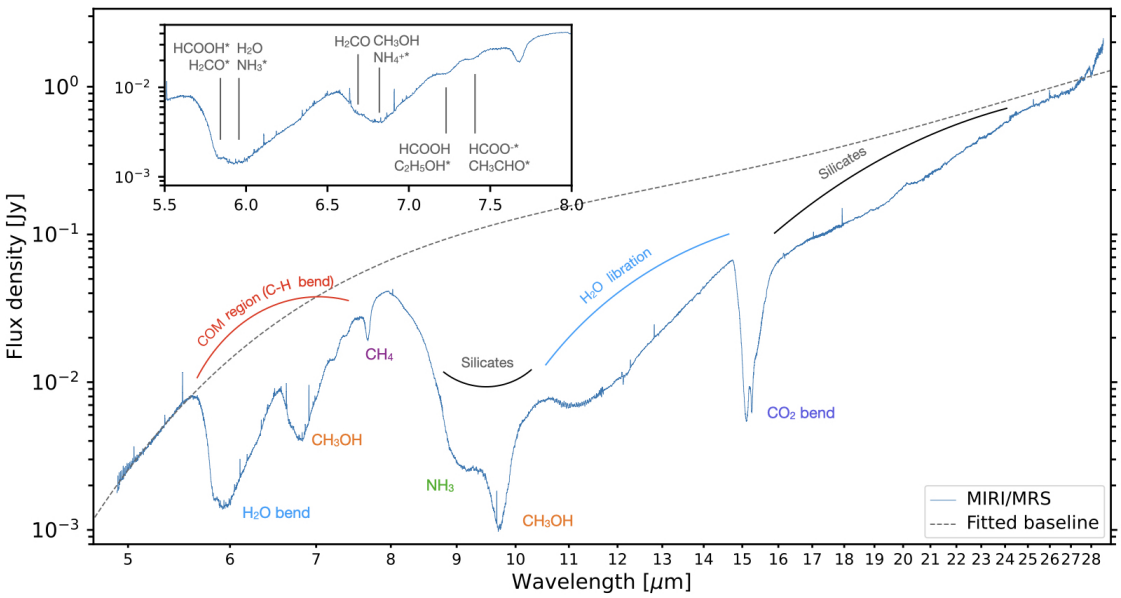

Figure 1: MIRI MRS spectrum of IRAS 15398-3359, showing various ice absorption features detected at the highest fidelity achieved to date.

References

[1] Y.-L. Yang, N. Sakai, Y. Zhang, et al. 2021, ApJ, 910, 20
[2] Y.-L. Yang, J. D. Green, K. M. Pontoppidan, et al. 2023, ApJL, 941, L13