

ALMA discovers a de-icing zone in a prestellar core

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Stars form in gravitationally bound condensations of interstellar molecular clouds. Condensations that not yet have a compact source of radiation but that are bound to collapse, are called prestellar cores. The physics and chemistry of these objects are studied to test core formation scenarios (quasi-static contraction or turbulent fragmentation) and to derive the time-scale of this process.

We present observations of selected chemical species towards a prestellar core in formation, obtained with the Atacama Large (Sub)millimeter Array (ALMA). The cold core ($T \sim 10$ K), probed by the line emission of deuterated ammonia (NH_2D), is surrounded by a thin gas layer producing strong methanol (CH_3OH) emission. In interstellar space, methanol can only be produced on grain surfaces, and its thermal evaporation from grains requires a temperature of $T \sim 80$ K. The presence of gaseous methanol in a cold core can be explained by some non-thermal desorption mechanism or by the passage of a shock in the recent past.

Our chemistry models indicate that the most viable non-thermal mechanism is desorption through exothermic surface reactions (Vasyunin et al. 2017). On the other hand, the occurrence of shocks at core boundaries would be a natural consequence of supersonic turbulence that pervades molecular clouds. This may be related to fact that several quiescent cores, including the target of the present study, show a sharp transition from supersonic to subsonic turbulence in a layer which could be called the core boundary (Goodman et al. 1998; Pineda et al. 2010). What happens in this layer is not well understood nor is it described in current (magneto-)hydrodynamic models of core formation. One possibility is that the kinetic energy of the gas is dissipated in radiative shocks.

Methanol is one of the most important precursors of complex organic molecules in interstellar gas. We predict, therefore, that the thin desorption layer discovered here contains also other saturated organic molecules, such as dimethyl ether (CH_3OCH_3) and methyl formate (HCOOCH_3), and would be an excellent target for a systematic exploration of molecular complexity in interstellar space.

References

Goodman et al. 1998, ApJ 504, 223

Pineda et al. 2010, ApJ, 712, L116

Vasyunin et al. 2017, ApJ 842, 33

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