Dissecting early phases of star formation

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Star formation is a long process. One of the first stages, called cold core, is characterized by medium density (a few 1e4 to 1e5 cm^{-3}), low temperature (15~K and below), and very low to no UV exposition. In these dense environments, a rich chemistry happens on interstellar dust grains. Species from the gas-phase can stick at their surface and further react to form complex organic molecules, such as methanol. Understanding these processes is essential to trace the origin of some molecules in space that cannot be formed by reactions in the gas-phase only. The desorption mechanisms of these species from the grains are not fully understood yet. Under such extreme conditions, thermal desorption is not possible as not enough energy is available. Several non-thermal desorption mechanisms (photo desorption, cosmic ray induced desorption, chemical desorption, radiolysis desorption) are studied in laboratory astrophysics (experiments or theoretical calculations) to give quantitative constraints that are then included in astrochemical models. With the arrival of a new generation of satellites and telescopes, it becomes easier and easier to unveil the mystery of the molecules desorptions as the abundances are now easier to obtain. Additionally, the unprecedented sensitivity of JWST will enable the observations of many lines of sight towards these sources yielding maps of the various ice constituents column densities.

Observing the cold cores L429C and L694, with IRAM 30m single dish telescope, we were able to constrain the gas-phase abundance of key species, such as CO and CH_3OH. We will compare them with the methanol ice abundance observed with Spitzer (L429C)[1] and with the NASA Infrared Telescope Facility (L694)[2]. Comparing the gas and ice abundances at the same positions allows us to put observational constraints on the non-thermal desorption mechanism of methanol as this molecule cannot be formed in the gas-phase. Comparing these results with the predictions of our chemical model nautilus, we will understand which non-thermal desorption mechanism dominates under these conditions if any.

Références

[1] Boogert et al., The Astrophysical Journal, Volume 729, Issue 2, article id. 92, 16 pp. (2011)

[2] Chu et al., The Astrophysical Journal, Volume 904, Issue 2, id.86, 18 pp.