Ice and gas modelizations in the cold core L429C

Angèle Taillard, Valentine Wakelam, Pierre Gratier, Jennifer Noble, Emmanuel Dartois, Marin Chabot, Jacqueline Keane, Adwin Boogert, Daniel Harsono

Abstract :

Star formation is a long process with one of the first stages, called cold core, characterized by medium density (a few 1e4 to 1e5 cm-3), low temperature (15~K and below), and low to no UV. In these dense environments, a rich chemistry happens at the surface of dust grains. Species from the gas-phase can stick at the surface of the grains 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 core L429C, with NOEMA and the IRAM 30m single dish telescope, we were able to constrain the gas-phase abundance of key species, such as CO and CH3OH, and compare it with the methanol ice abundance observed with Spitzer in the same region. Comparing the gas and ice abundances at the same positions allows us to put observational constraints on the non-thermal desorption mechanisms of methanol as this molecule cannot be formed in the gas-phase. Comparing these results with the predictions of our chemical model nautilus, we try to understand which non-thermal desorption mechanism dominates under these conditions if any.