A sulfur journey across star-forming regions: study of thioformaldehyde emission

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Within the IRAM 30m Large Program GEMS (Gas phase Elemental abundances in Molecular CloudS), we present a study of (deuterated) thioformaldehyde in several starless cores located in a selected set of star-forming filaments of Taurus, Perseus, and Orion. These regions have different star formation activity and, therefore, distinct physical and chemical conditions. We have modeled the observed lines of H_2CS, HDCS, and D_2CS using the radiative transfer code RADEX. We have also used the chemical code Nautilus to model the evolution of these species depending on the characteristics of the starless cores.

Our results indicate that the north region of the B213 filament in Taurus is more evolved than the south, while the northeastern part of Perseus presents an earlier evolutionary stage than the southwestern. Model results also show that Dfrac decreases with the cosmic ionization rate, while it increases with density and with the degree of sulfur depletion. In particular, we only reproduce the observations when the initial sulfur depletion in the starless cores is at least one order of magnitude lower than the solar elemental sulfur abundance. The progressive increase of HDCS/H_2CS and D_2CS/H_2CS with time makes these ratios powerful tools to derive the evolutionary stage of starless cores. Not like that though to derive the temperature of these regions, since both ratios present a similar trend evolution at two different ranges of temperature (~7-11 K and ~15-19 K). Regarding chemistry, (deuterated) thioformaldehyde is mainly formed through gas-phase reactions (double-replacement and neutral–neutral displacement reactions), while surface chemistry (depletion) plays an important role as a destruction mechanism.

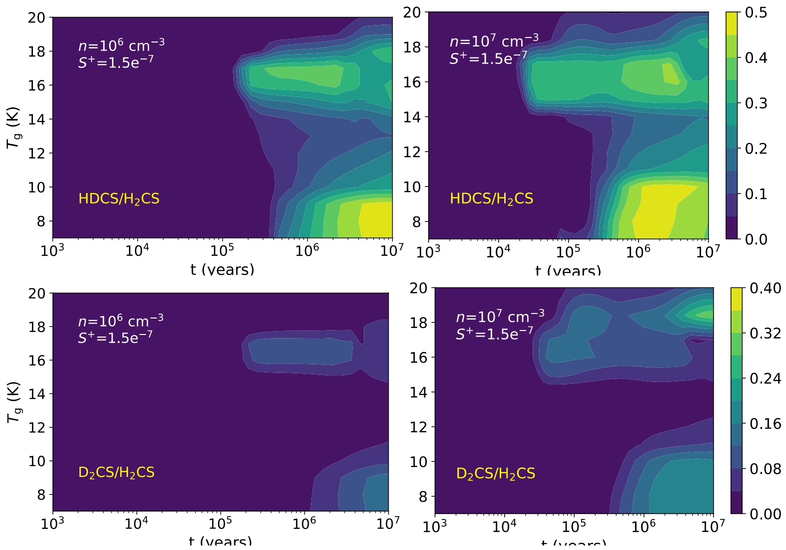

Figure: Evolution of the HDCS/H_2CS and D_2CS/H_2CS ratios as a function of time and temperature for a cosmic-ray ionization rate ξ=1.3×10^{-17}.