Formation and recondensation of complex organics during protostellar outbursts

Vianney Taquet*[1]

[1]Leiden Observatory – J.H. Oort Building Niels Bohrweg 2 NL-2333 CA Leiden, Pays-Bas

Résumé

During the formation of stars, the accretion of the surrounding material toward the central object is thought to undergo frequent and strong eruptive outbursts, followed by long periods of relative quiescence. Such episodic events have been invoked to resolve the "luminosity problem" whereby the observed luminosity of most low-mass protostars is lower than the accretion luminosity expected from theoretical collapse models (Dunham et al. 2010). The recent detection of a luminosity outburst toward the embedded Class 0 protostar HOPS 383 by Safron et al. (2015) confirms that luminosity outbursts can occur at the earliest stages of star formation when the protostar is still surrounded by a massive envelope. As a consequence, strong and sudden changes in the protostellar luminosity are thought to influence the chemical evolution in the surrounding envelope.

We investigated the formation and the recondensation of complex organics, including dimethyl ether and methyl formate, during protostellar luminosity outbursts. For this purpose, we updated a gas phase chemical network forming complex organics triggered by the evaporation of interstellar ices. In particular, we updated the rates and branching ratios of electronic recombination reactions, following laboratory experiments, and introduced proton transfer reactions involving ammonia, not included in databases, forming complex organics. It is found that gas phase chemistry is efficient enough to produce COMs with absolute abundances higher than 10ˆ-8 in spite of the short luminosity outburst timescales of a few hundreds years. The low binding energies of the studied COMs relative to water and methanol delays their recondensation and increases their abundance ratios with respect to methanol. Comparison with observations shows that models assuming constant physical properties are only able to reproduce the observed abundance ratios of a few percents at high methanol abundances. Models predicting the formation of COMs during luminosity outbursts for high density conditions are able to reproduce the abundance ratios higher than 10 % obtained at moderate methanol abundances. Although the current luminosity of most embedded protostars would be too low to produce observable hot cores, previous and recent luminosity outburst events would induce a formation of COMs in expanded regions with sizes increasing by one order of magnitude.

*Intervenant