Dynamic assembly of cometary ices in protoplanetary disk midplanes

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Protoplanetary disk midplanes harbor the largest reservoir of icy dust grains that will be incorporated into planetary embryos and comets. The chemical content of these midplane ices originates in the prestellar phase and is shaped during the dynamic transport towards the disk upon the onset of collapse, as shown by means of a sophisticated physicochemical model [1, 2]. In this talk, results for two protoplanetary disks, one grown predominantly via viscous spreading and another via pure infall, will be shown. The models predict that the amount of CO_2 can increase during infall via the grain-surface reaction of OH with CO, which is enhanced by photodissociation of H_2O ice. Complex organic ices can be produced at abundances as high as a few % of H_2O ice at large disk radii (R > 30 AU) at the expense of CH_3OH ice, meaning that current Class II disc models may be underestimating the complex organic content. These simulations immediately imply that planet population synthesis models may underestimate the amount of CO_2 and overestimate CH_3OH ices in planetesimals by disregarding chemical processing between the cloud and disk phases. The model results are used to derive the C/O and C/N ratios as a function of radius in midplanes of embedded disks and are predicted to differ between the gas and solid phases. The two ice ratios show little variation beyond the inner 10 AU and both are nearly solar in the case of pure infall (Fig. 1), but both are sub-solar when viscous spreading dominates. These models highlight the importance of dynamics and chemistry in the embedded phase of star and planet formation for the chemical budget of comets and planetary building blocks.

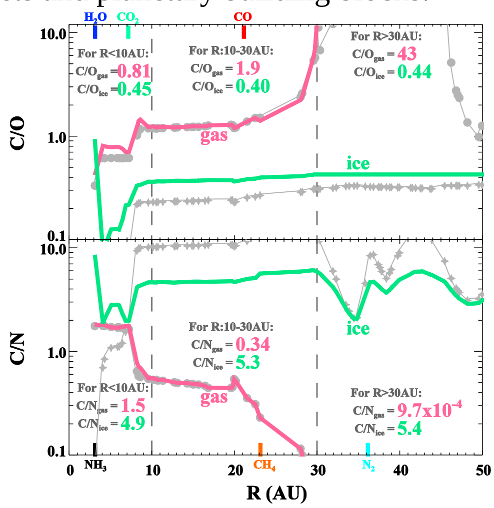

Figure 1: The midplane C/O and C/N ratios as a function of disc radius (R) in the gaseous (coral colored lines) and solid (turquoise colored lines) phases at the end of the simulation (2.46×10^5 yr after the onset of collapse) for the infall-dominated disk. The locations of some snowlines are marked. The grey curves with dots and stars are the ratios in the gaseous and solid phases, respectively, as calculated with abundances of simple volatiles only (namely H_2O, CO, CO_2, CH_3OH, CH_4, N_2 and NH_3 only).

References

[1] M.N. Drozdovskaya, C. Walsh, R. Visser, D. Harsono, E.F. van Dishoeck, 2014, MNRAS 445, 913.

[2] M.N. Drozdovskaya, C. Walsh, E.F. van Dishoeck, K. Furuya, U. Marboeuf, A. Thiabaud, D. Harsono, R. Visser, 2016, MNRAS 462, 977.