Colloquium

SFB 956

Conditions and Impact of Star Formation

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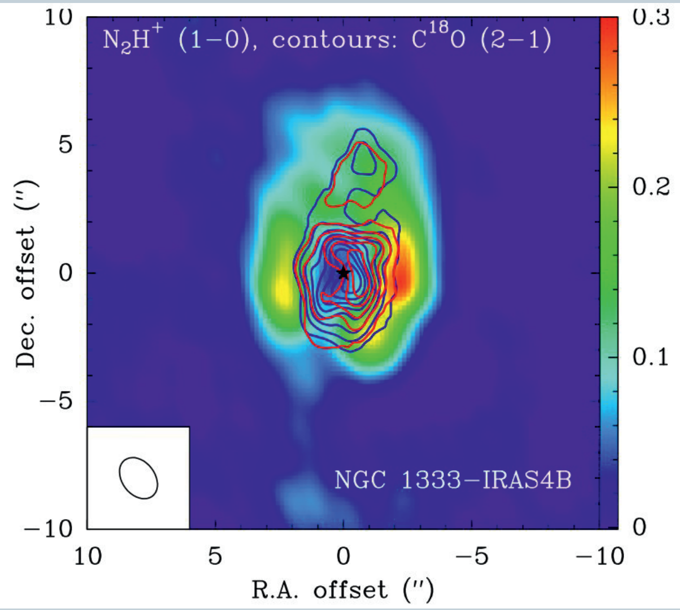

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Probing the Methanol and CO Snow Lines in the Young Protostar NGC 1333-IRAS4B

One central question in the context of star formation concerns the evolution of complex chemistry that could eventually trigger the onset of life. In the interstellar medium, complex organic molecules seem to mostly form in reactions happening on the icy surface of dust grains, such that they are released into the gas phase when the dust is heated. The resulting "snow lines", marking regions where ices start to sublimate, play an important role for planet growth and bulk composition in protoplanetary disks. However, they can already be observed in the envelopes of the much younger, low-mass Class 0 protostars that are still in their early phase of heavy accretion. The information on the sublimation regions of different kinds of ices can be used to understand the chemistry of the envelope, its temperature and density structure, and may even hint at the history of the accretion process. Accordingly, it is a crucial piece of information in order to get the full picture of how organic chemistry evolves already at the earliest stages of the formation of sun-like stars. As part of the CALYPSO Large Program (cf. http:/irfu.cea.fr/Projets/Calypso/), we have obtained observations of $C^{18}O$, $N2H^+$ and CH_3OH towards the Class 0 protostar NGC 1333-IRAS4B with the IRAM Plateau de Bure interferometer at sub-arcsecond resolution. We observe an anti-correlation of $C^{18}O$ and N_2H^+, with N_2H^+ forming a ring (perturbed by the outflow) around the centrally peaked $C^{18}O$ emission. This reveals the CO snow line in this protostellar envelope with unprecedented resolution, with a radius of ~300 AU. In addition, we observe compact methanol emission, with a radius of ~40 AU. We have modeled the emission using a chemical model coupled with a radiative transfer module, using the temperature and density profiles self-consistently determined by Kristensen et al. (2012). We find that the CO snow line appears further inwards than expected from the binding energy of pure CO ices. This may hint at CO being frozen out in H_2O or CO_2 dominated ices. Our observations can thereby yield clues on the widely unknown composition of interstellar ices, being the initial seeds of complex organic chemistry.

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