Ice in space; laboratory astrophysics in the era of the James Webb Space Telescope

Harold Linnartz[1]. LfA and ICE AGE Team
[1]*Laboratory for Astrophysics, Leiden Observatory, Leiden University, PO Box 9513, NL2300 RA*
Email: linnartz@strw.leidenuniv.nl

In 2022, the JWST has been unveiling the dark side of pre-stellar chemistry in a dedicated survey of the Chameleon I molecular cloud.[1] Using the MIRI instrument, it was possible to identify interstellar ice components in pre-stellar regions, i.e., environments not participating in the star- and planet formation process.[1] Such astronomical data can only be interpreted following dedicated spectroscopic laboratory studies, recording IR spectra, deriving absorption cross sections and optical parameters for interstellar ice analogues, typically at temperatures as low as 15K. These are publically available from the Leiden Ice Database of Astrochemistry (LIDA: https://icedb.strw.leidenuniv.nl/).[2] In this way information is obtained on ice morphology (composition and structure) as well as molecular abundances. Laboratory studies, however, not only provide the tools to interpret astronomical observations, in parallel these also allow to quantitatively characterize the physical and chemical processes at play, i.e. photodesorption rates and reaction rates. Ultimately these determine the chemical evolution in star forming regions and as such are key in the chemical composition of (exo)planets and their atmospheres. A special focus in laboratory astrophysics has been on the formation of so called i-COMs, interstellar Complex Organic Molecules, that form on icy dust grains through radical-molecule reactions, triggered by impacting atoms, UV photons, electrons or cosmic rays.[3] The laboratory characterization of these processes makes it possible to link the astronomical snapshots towards different evolutionary stages along different lines of sight in large interstellar clouds.

References

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