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Abstracts

First map of D2H+ emission revealing the true centre of a prestellar core: Further insights into deuterium chemistry

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Context. IRAS 16293E is a rare case of a prestellar core being subjected to the effects of at least one outflow. Aims. We want to disentangle the actual structure of the core from the outflow impact and evaluate the evolutionary stage of the core. Methods. Prestellar cores being cold and depleted, the best tracers of their central regions are the two isotopologues of the trihydrogen cation that are observable from the ground: ortho–H2D+ and para–D2H . We used the Atacama Pathfinder EXperiment (APEX) telescope to map the para–D2H+ emission in IRAS 16293E and collected James Clerk Maxwell Telescope (JCMT) archival data of ortho–H2D+ . We compared their emission to that of other tracers, including dust emission, and analysed their abundance with the help of a 1D radiative transfer tool. The ratio of the abundances of ortho–H2D+ to para–D2H+ can be used to estimate the stage of the chemical evolution of the core. Results. We have obtained the first complete map of para–D2H+ emission in a prestellar core. We compare it to a map of ortho–H2D+and show their partial anti-correlation. This reveals a strongly evolved core with a para–D2H+/ortho–H2D+ abundance ratio towards the centre for which we obtain a conservative lower limit from 3.9 (at 12 K) to 8.3 (at 8 K), while the high extinction of the core is indicative of a central temperature below 10 K. This ratio is higher than predicted by the known chemical models found in the literature. Para–D2H+ (and indirectly ortho–H2D+) is the only species that reveals the true centre of this core, while the emission of other molecular tracers and dust are biased by the temperature structure that results from the impact of the outflow. Conclusions. This study is an invitation to reconsider the analysis of previous observations of this source and possibly questions the validity of the deuteration chemical models or of the reaction and inelastic collisional rate coefficients of the H3+ isotopologue family. This could impact the deuteration clock predictions for all sources.

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Q-band Line Survey Observations toward a Carbon-chain-rich Clump in the Serpens South Region

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We have conducted Q-band (30 GHz − 50 GHz) line survey observations toward a carbon-chain emission peak in the Serpens South cluster-forming region with the extended Q-band (eQ) receiver installed on the Nobeyama 45 m radio telescope. Approximately 180 lines have been detected including tentative detection, and these lines are attributed to 52 molecules including isotopologues. It has been found that this position is rich in carbon-chain species as much as Cyanopolyyne Peak in Taurus Molecular Cloud-1 (TMC-1 CP), suggesting chemical youth. Not only carbon-chain species, but several complex organic molecules (CH3OH, CH3CHO, HCCCHO, CH3CN, and tentatively C2H3CN) have also been detected, which is similar to the chemical complexity found in evolved prestellar cores. The HDCS/H2CS ratio has been derived to be 11.3±0.5 %, and this value is similar to the prestellar core L1544. The chemically young features that are similar to the less-dense starless core TMC-1 CP (1e4 cm−3 − 1e5 cm−3) and chemically evolved characters which resemble the dense prestellar core L1544 (~1e6 cm−3) mean that the clump including the observed position is a pre-cluster clump without any current star formation activity.

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The SOFIA Massive (SOMA) Star Formation Q-band Follow-up. I. -Carbon-Chain Chemistry of Intermediate-Mass Protostars-

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Evidence for similar chemical characteristics around low- and high-mass protostars has been found: in particular, a variety of carbon-chain species and complex organic molecules (COMs) are formed around them. On the other hand, the chemical compositions around intermediate-mass (IM; 2M⊙<m∗<8M⊙) protostars have not been studied with large samples. In particular, it is unclear the extent to which carbon-chain species are formed around them. We aim to obtain the chemical compositions, particularly focusing on carbon-chain species, towards a sample of IM protostars. We have conducted Q-band (31.5-50 GHz) line survey observations towards eleven mainly intermediate-mass protostars with the Yebes 40 m radio telescope. The target protostars were selected from a sub-sample of the source list of the SOFIA Massive (SOMA) Star Formation project. Nine carbon-chain species (HC3N, HC5N, C3H, C4H, linear−H2CCC, cyclic−C3H2, CCS, C3S, and CH3CCH), three COMs (CH3OH, CH3CHO, and CH3CN), H2CCO, HNCO, and four simple sulfur (S)-bearing species (13CS, C34S, HCS+, H2CS) have been detected. The rotational temperatures of HC5N are derived to be ~20−30 K in three IM protostars and they are very similar compared to those around low- and high-mass protostars. These results indicate that carbon-chain molecules are formed in lukewarm (~20−30 K) gas around the IM protostars by the Warm Carbon-Chain Chemistry (WCCC) process. Carbon-chain formation occurs ubiquitously in the warm gas around protostars across a wide range of stellar masses. Carbon-chain molecules and COMs coexist around most of the target IM protostars, which is similar to the situation in low- and high-mass protostars. The chemical characteristics around protostars are common in the low-, intermediate- and high-mass regimes.

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Infrared spectra of solid-state ethanolamine: Laboratory data in support of JWST observations

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Ethanolamine (NH2CH2CH2OH, EA) has been identified in the gas phase of the ISM within molecular clouds. Although EA has not been directly observed in the molecular ice phase, a solid state formation mechanism has been proposed. However, the current literature lacks an estimation of the infrared band strengths of EA ices. We conducted an experimental investigation of solid EA ice at low temperatures to ascertain its infrared band strengths, phase transition temperature, and multilayer binding energy. The commonly used laser interferometry method was not applied. Infrared band strengths were determined using three distinct methods. The obtained lab spectrum of EA was compared with the publicly available MIRI MRS James Webb Space Telescope observations toward a low mass protostar. The phase transition temperature for EA ice falls within the range of 175 to 185 K. Among the discussed methods, the simple pressure gauge method provides a reasonable estimate of band strength. We derive a band strength value of about 1e−17 cm molecule−1 for the NH2 bending mode in the EA molecules. Additionally, temperature-programmed desorption analysis yielded a multilayer desorption energy of 0.61±0.01 eV. By comparing the laboratory data documented in this study with the JWST spectrum of the low mass protostar IRAS 2A, an upper-limit for the EA ice abundances was derived.

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