

## Microwave spectroscopy of complex molecules around the young protostar Chamaeleon MMS1

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Observations are presented of emission lines from organic molecules at frequencies 30-100 GHz in the vicinity of the extremely young, chemically rich, very low-luminosity protostar and candidate first hydrostatic core Chamaeleon MMS1. Column densities are derived and emission maps are presented for species including polyynes, cyanopolyynes, sulphuretted carbon-chains and methanol. Emission from the carbon-chain-bearing species peaks very near to the protostar; methanol peaks about 0.1 pc further away. The mean molecular hydrogen number density is calculated to be  $10^6$  per cc. and the gas kinetic temperature is in the range 4-7 K. The abundances of long carbon chains (including C<sub>6</sub>H and HC<sub>7</sub>N) are very large -- similar to those found in the most carbon-chain-rich regions of the Galaxy, and indicative of a non-equilibrium carbon chemistry. The observed methanol and acetaldehyde abundances indicate active grain-surface chemistry and desorption processes. The carbon-chain anions C<sub>4</sub>H<sup>-</sup> and C<sub>6</sub>H<sup>-</sup> were not detected and the upper limit on the anion-to-neutral ratio for C<sub>4</sub>H<sup>-</sup> is less than 0.02% and for C<sub>6</sub>H<sup>-</sup>, less than 10%. These values are consistent with previous observations in interstellar clouds and low-mass protostars. Deuterated HC<sub>3</sub>N and c-C<sub>3</sub>H<sub>2</sub> were detected, with fractionation ratios of about 4%, and 22%, respectively. A low c-C<sub>3</sub>H<sub>2</sub> ortho-to-para ratio was measured, which is consistent with a molecular hydrogen ortho-to-para ratio of close to zero and implies a relatively young chemical age (less than about  $10^5$  yr) for the matter surrounding Cha-MMS1. These observations show that a high level of chemical complexity can be present in star-forming gas.

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