

NON-LTE SPECTROSCOPY OF METHANE RECORDED IN A HYPERSONIC FLOW

E. DUDÁS, **N. SUAS-DAVID**, **L. ROLLAND**, **R. GEORGES**, *IPR, Université de Rennes, UMR6251 CNRS, F-35042, France*; **B. VISPOEL**, *Research Unit Lasers and Spectroscopies (LLS), Institute of Life, Earth and Environment (ILEE), University of Namur (UNamur), 61 rue de Bruxelles, B-5000, Namur, Belgium*; **R. R. GAMACHE**, *Department of Environmental, Earth, and Atmospheric Sciences University of Massachusetts Lowell, Lowell, MA 01854 USA*; **M. REY**, *GSMA, UMR 7331, Université de Reims, Reims, France*; **V. TYUTEREV**, **A. NIKITIN**, *V.E. Zuev Institute of Atmospheric Optics SB RAS, Tomsk, 634055, Russia*; **S. KASSI**, *LIPhy, UMR 5588, Université Grenoble Alpes, Saint Martin d'Hères, France*

Laboratory spectroscopic data is essential for the modeling of hot exoplanet atmospheres, since molecules such as methane, a major component of hot-Jupiter-type exoplanet atmospheres, have a complex vibrational energy structure that makes computational predictions difficult at high temperatures for ro-vibrational transitions involving highly excited vibrational states. To better inform line lists used in radiative transfer modelling, the ro-vibrational spectrum of methane has been recorded in the tetradecad region between 1.7 and 1.65 μm ($5880\text{--}6060\text{ cm}^{-1}$) through non-local thermodynamic equilibrium (non-LTE) cavity ringdown spectroscopy (CRDS)¹. Non-LTE conditions, characterized by a low rotational temperature (39 K) and a high vibrational temperature (up to 1130 K), have been obtained by hypersonic expansion of a pre-heated mixture of argon and methane in a contoured Laval nozzle. The high vibrational temperature increases the intensity of new hot bands, while the very low rotational temperature greatly simplifies their rotational structure, thus facilitating their identification. A close comparison of the recorded CRDS data to the TheoReTS database reveals both inefficient vibrational relaxation between polyads and efficient vibrational relaxation between vibrational states forming a polyad. These effects result in an overpopulation of the lowest vibrational energy level of each polyad, an effect not widely currently incorporated in non-LTE radiative transfer models. A series of new hot band transitions originating from the pentad and octad polyads were assigned and are provided as a line list for use in future databases².

¹[doi:10.1063/5.0003886](https://doi.org/10.1063/5.0003886), E. Dudás *et al.*, *J. Chem. Phys.*, 152, 134201 (2020).

²[doi:10.1016/j.icarus.2022.115421](https://doi.org/10.1016/j.icarus.2022.115421), E. Dudás *et al.*, *Icarus*, 394, 115421 (2023).