

# Understanding the atmosphere of hot Jupiter exoplanets: high resolution spectroscopy of ethylene in the 1.6 $\mu\text{m}$ spectral region

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The hot Jupiter exoplanets are giant gas planets orbiting very closely to their star, leading to external temperatures up to 3000 kelvins. Methane [1] and acetylene [2] were already detected in such environments, and the presence of other small hydrocarbons is expected. The recent launch of the James Webb Space Telescope (JWST) and the upcoming Ariel mission will allow a better understanding of their atmospheric composition using infrared spectrometry [3]. Interpretation of these observations will require accurate knowledge of the absorption fingerprint of the expected species. In the case of ethylene ( $\text{C}_2\text{H}_4$ ), unambiguous spectral assignment in the near infrared is not available beyond  $3500\text{ cm}^{-1}$  [4].

We focus on providing accurate assignments of the ethylene cold transitions. We use a cavity ring-down spectrometer to probe the cold gas in the 1.65-1.68  $\mu\text{m}$  spectral range. The low temperature is obtained by expanding the gas contained in a high-pressure reservoir into a low-pressure chamber through an 80 mm long and 100  $\mu\text{m}$  wide slit. This process enables a simplification of the absorption spectrum by reducing the number of excited transitions and by narrowing the linewidths. Figure 1 shows the cold spectrum (red markers) that was obtained by using 20 slm of Ar buffer gas, 1 slm of  $\text{C}_2\text{H}_4$  initially at room temperature. The measured line widths were used to estimate the sample temperature to 13 K. Unambiguous assignment of the observed lines will later be performed using the two-temperature method [5]. Hence, we repeated the experiment at 24 K, by using 20 slm of Ar buffer gas, 3 slm of  $\text{C}_2\text{H}_4$  preheated at  $160^\circ\text{C}$  prior to the expansion. The resulting spectrum is shown in black: 'hot' transitions have emerged and the discrepancy between the intensities of the two cold transitions is inverted. The produced assignment will be later compared to the TheoReTS simulations [6], which will provide ethylene line lists at temperatures relevant to the hot Jupiters.

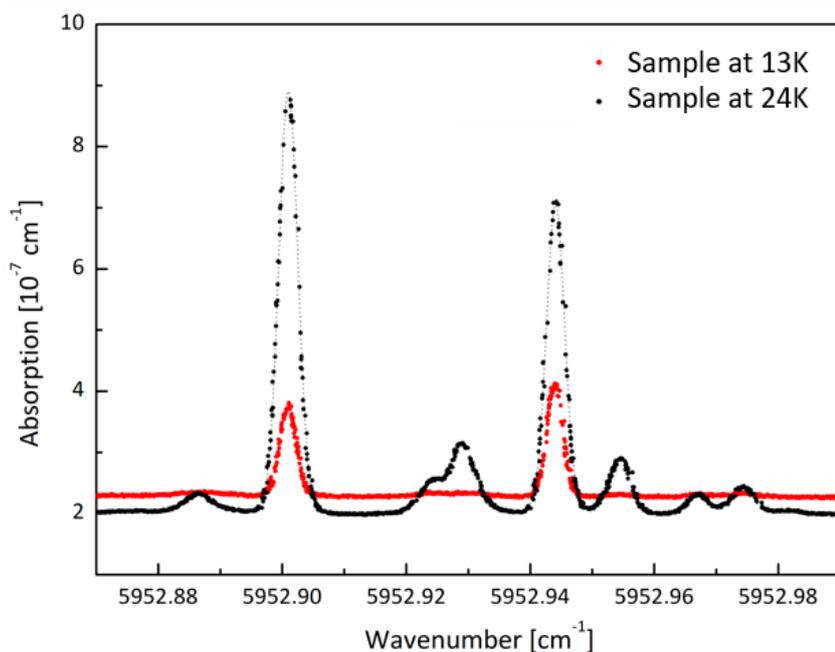


Figure 1: Recorded spectra of  $\text{C}_2\text{H}_4$  at different temperatures: 13K (red) and 24K (black), emphasizing the appearance of absorption lines belonging to hot bands when the gas is heated.

[1] M. R. Swain, G. Vasisht, G. Tinetti, *Nature*, **463** (7281), 637-639 (2008)

[2] P. Giacobbe, *et al.*, *Nature*, **592** (7853), 205-208 (2021)

[3] see <https://www.jwst.nasa.gov/> and <https://arielmision.space/>

[4] I.E. Gordon, *et al.*, *J. Quant. Spectrosc. Radiat. Transfer*, **277**, 107949 (2022)

[5] S. Kassı, B. Gao, D. Romaninia and A. Campargue, *Phys. Chem. Chem. Phys.*, **10**, 4410-4419 (2008)

[6] M. Rey, A. V. Nikitin, Y. L. Babikov, and V. G. Tyuterev, *J. Mol. Spectrosc.*, **327**, 138-158 (2016)

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