SUPERSONIC JETS PROBED WITH CAVITY-ENHANCED FREQUENCY COMB SPECTROSCOPY

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Supersonic jets are a powerful tool to efficiently cool down molecular gas samples down to a few kelvins, hence simplifying their rovibrationnal spectra. This is especially needed when studying large molecules of astrophysical interest. Spectroscopic techniques based on optical frequency combs then provide high resolution, high sensitivity and broad spectral coverage required to probe such cold expansions[1 2 3].

We demonstrate comb-based Fourier transform spectroscopy of acetylene at 1.55 μm in a slit nozzle expansion, with argon as the buffer gas. The comb had a repetition rate $f_{rep} =$ 100 MHz, and was coupled to a $\sim$ 350 finesse cavity with a free spectral range of 150 MHz, yielding a filtered comb mode spacing of 300 MHz. This value being close to the width of acetylene lines at $\sim$ 10 K, we retrieved individual comb modes intensities with the subnominal technique[4] and interleaved spectra acquired with incremental f_{rep} values to fully resolve line profiles. At each f_{rep} step, 40 spectra were acquired and averaged for a total of 19 steps evenly spaced in frequency. The figure below displays the transmission spectrum (black trace) fitted with a cavity transmission model and Voigt profiles computed with HITRAN2020 parameters[5] (red trace). The fit yielded temperatures of 6 K for the supersonic expansion isentropic core and of 230 K for the shear layers of the expansion.

The experimental setup will be discussed along the data processing and analysis. Outlooks for the technique with mid-infrared combs will be considered.

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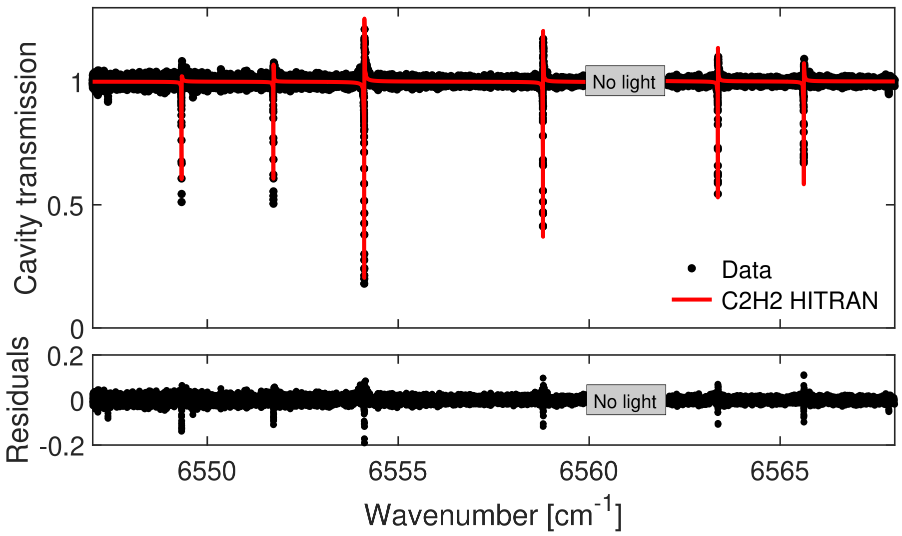
[1] doi:10.1016/j.cplett.2008.11.064, M. J. Thorpe *et al.*, "Tomography of a supersonically cooled molecular jet using cavity-enhanced direct frequency comb spectroscopy", *Chem. Phys. Lett.*, **468**, 1–8, (2009).

[2] doi:10.1364/OPTICA.3.000311, M. A. R. Reber, Y. Chen and T. K. Allison, "Cavity-enhanced ultrafast spectroscopy: ultrafast meets ultrasensitive", *Optica*, **3**, 311–317, (2016).

[3] doi:10.1080/00268976.2022.2094297, J. Agner *et al.*, "High-resolution spectroscopic measurements of cold samples in supersonic beams using a QCL dual-comb spectrometer*", *Mol. Phys.*, **120**(15–16), (2022).

[4] doi:10.1016/j.jqsrt.2017.09.001, L. Rutkowski *et al.*, "Optical frequency comb Fourier transform spectroscopy with sub-nominal resolution and precision beyond the Voigt profile", *J. Quant. Spectrosc. Radiat. Transfer*, **204**, 63–73, (2022).

[5] doi:10.1016/j.jqsrt.2021.107949, I.E. Gordon *et al.*, "The HITRAN2020 molecular spectroscopic database", *J. Quant. Spectrosc. Radiat. Transfer*, **277**, 107949, (2022).



Cavity transmission
1
0.5
0
No light
Data
C2H2 HITRAN
Residuals
0.2
0
-0.2
6550
6555
6560
6565
Wavenumber [cm^{-1}]