DUAL-COMB SPECTROSCOPY IN THE TWO-MICRON RANGE USING A NOVEL DESIGN OF DISPERSION-CONTROLLED HIGHLY NONLINEAR FIBRE

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Over the past few decades, dual-comb spectroscopy (DCS) has garnered significant interest due to its ability to enable precise and real-time gas detection [1]. This technique finds applications in various fields such as breath analysis, air pollutant detection, agricultural gas flux measurement, or material characterization to cite a few. Moreover, the availability of mature components operating at 1.55 μm has greatly facilitated the development of spectrometers based on DCS. However, certain molecular species, like CO_2, exhibit a very low absorption in this spectral window, necessitating long absorption lengths to detect them effectively. Hence, there is a need to convert the frequency combs to a more suitable spectral window, preferably around 2 μm or beyond, to combine the component maturity at 1.55 μm with efficient absorption in the mid-infrared region.

In this study, we employ the phenomenon of degenerate four-wave mixing [2] in a specially designed dispersion-controlled highly nonlinear fiber to convert our frequency combs in the two-micron region [3]. This approach enables us to measure the rotational-vibrational absorptions of $^{12}C^{16}O_2$ and $^{14}N_2^{16}O$ and extract the self-broadening coefficients associated with these molecules. A study is also performed on a mixture $^{12}C^{16}O_2$/$^{14}N_2^{16}O$, in order to measure the broadening of the CO_2 peaks due to the presence of N_2O. Our results are in very good agreement with the HITRAN database, showing the performance of the proposed dual-comb spectrometer.

[1] G. Millot *et al.*, "Frequency-agile dual-comb spectroscopy", Nature Photonics, 10, 27 (2016)

[2] S. Pitois *et al.*., "Experimental observation of a new modulation instability spectral window induced by fourth-order dispersion in a normally dispersive single-mode optical fiber", Optics Communications, 226,415-422 (2003)

[3] S.E. Ahmedou *et al.*, "Design and fabrication of dispersion controlled highly nonlinear fibers for far-detuned four-wave mixing frequency conversion",Optics Express, 30, 6 (2023)