HIGH-RESOLUTION DUAL-COMB SPECTROSCOPY WITH ULTRA-LOW NOISE FREQUENCY COMBS

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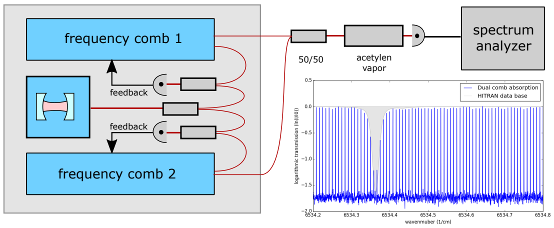

Dual-comb spectroscopy is a powerful tool for fast broad-band spectroscopy due to the parallel interrogation of thousands of spectral lines. Here we report on the spectroscopic analysis of acetylene vapor in a pressurized gas cell using two ultra-low noise frequency combs with a repetition rate around 250 MHz. Optical referencing to a high-finesse cavity yields a sub-Hertz stability of all individual comb lines (including the virtual comb lines between 0 Hz and the carrier) and permits one to pick a small difference of repetition rate for the two frequency combs on the order of 300 Hz, thus representing an optical spectrum of 100 THz ($\sim$3300 cm^{-1}) within half the free spectral range (125 MHz). The transmission signal is derived straight from a photodetector and recorded with a high-resolution spectrum analyzer or digitized with a computer-controlled AD converter. The figure to the right shows a schematic of the experimental setup which is all fiber-coupled with polarization-maintaining fiber except for the spectroscopic cell. The graph on the lower right reveals a portion of the recorded radio-frequency spectrum which has been scaled to the optical domain. The location of the measured absorption coincides well with data taken from the HITRAN data base. Due to the intrinsic linewidth of all contributing comb lines, each sampling point in the transmission graph corresponds to the probing at an optical frequency with sub-Hertz resolution. This resolution is maintained in coherent wavelength conversion processes such as difference-frequency generation (DFG), sum-frequency generation (SFG) or non-linear broadening (self-phase modulation), and is therefore easily transferred to a wide spectral range from the mid infrared up to the visible spectrum.