# Noise-Immune Cavity-Enhanced Optical Frequency Comb Spectroscopy

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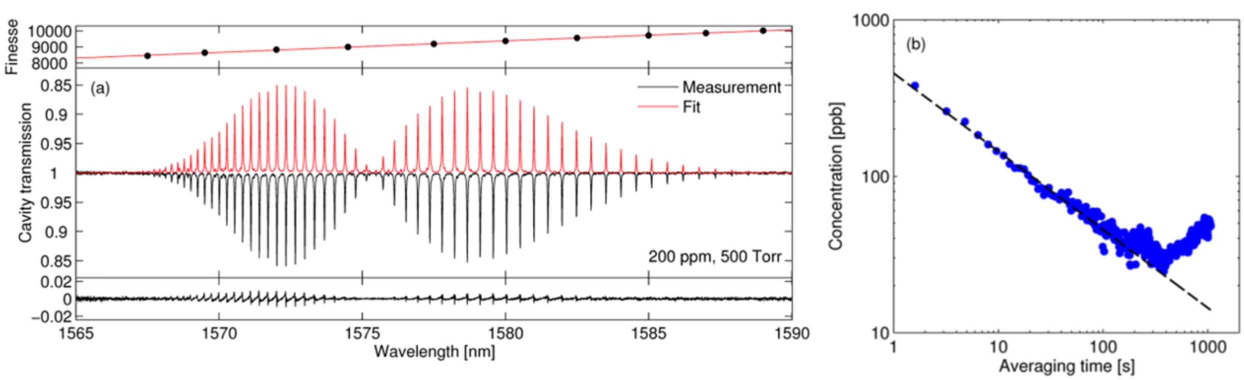
We present noise-immune cavity-enhanced optical frequency comb spectroscopy (NICE-OFCS), a new technique of sensitive, broadband, and high resolution spectroscopy [1]. In NICE-OFCS a frequency comb is locked to a high-finesse cavity and phase-modulated at a frequency equal to (a multiple of) the cavity free spectral range (FSR). Since each comb line and sideband is transmitted through a separate cavity mode in exactly the same way, residual frequency noise on the comb relative to the cavity affects each component equally. The transmitted intensity contains a beat signal at the modulation frequency that is immune to frequency-to-amplitude noise conversion by the cavity, similar to continuous wave NICE-OHMS [2]. Our NICE-OFCS system is based on an Er:fiber femtosecond laser (repetition rate of 250 MHz), a cavity (FSR of 187.5 MHz, finesse of ~9000 [Fig. (a)]), and a fast-scanning Fourier-transform spectrometer with a high-bandwidth commercial detector. The comb is locked to the cavity using the two-point Pound-Drever-Hall technique [3] and phase-modulated at a frequency of 562.5 MHz, generated by a direct digital synthesizer referenced to a harmonic of the comb repetition rate [4]. The NICE-OFCS signal is obtained by fast Fourier transform of a synchronously demodulated interferogram. We measured NICE-OFCS signals from the 3ν1+ν3 overtone band of $CO_2$ around 1.57 μm [shown in Fig. (a) together with a fit and residual], and achieved absorption sensitivity of $6.4 \times 10^{-11}$ $cm^{-1}$ $Hz^{-1/2}$ per spectral element, corresponding to a minimum detectable $CO_2$ concentration of 25 ppb after 330 s [Fig. (b)]. We will describe the principles of the technique and its technical implementation, and discuss the spectral lineshapes of the signals.




References

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