FIBER-LASER-BASED NICE-OHMS FOR TRACE GAS DETECTION

A. FOLTYNOWICZ, W. MA, and O. AXNER, *Department of Physics, Umeå University, SE-907 87 Umeå, Sweden*.

Noise-immune cavity-enhanced optical heterodyne molecular spectroscopy (NICE-OHMS) is an absorption technique that combines frequency modulation (FM) for reduction of noise with cavity enhancement for increased interaction length with the sample to provide ultra-high detection sensitivity.[ab] The carrier of the FM triplet is locked to a mode of an external cavity and the FM modulation frequency is matched to the cavity free spectral range (FSR), thus the sidebands are transmitted through adjacent cavity modes. As a result any residual frequency noise of the laser carrier leads to the same amplitude attenuation and phase shift of the sidebands, wherefore FM spectroscopy can be performed inside the cavity without introduction of additional noise, yet benefiting from the cavity enhancement of length and laser power.

The main technical difficulty of NICE-OHMS is the locking of the laser frequency to a cavity mode. We will present a recently developed compact NICE-OHMS spectrometer based on an erbium-doped fiber laser, whose narrow linewidth (1 kHz/120 μs) simplifies the locking procedure significantly.[c] The use of integrated-optics devices, such as a fiber-coupled electro-optic modulator, further reduces the complexity of the system.

The fiber-laser-based NICE-OHMS spectrometer is capable of detecting both Doppler-broadened and sub-Doppler signals with a sensitivity in the 10^{-11} cm^{-1} range, using a cavity with a finesse of 4800.[de] The two detection modes will be compared and experimental results from C_2H_2 and CO_2 at 1531 nm under low pressure conditions will be presented. The dependence of signal strengths and shapes on analyte concentration and other experimental parameters (such as intracavity power and pressure, cavity FSR and FM detection phase), as well as the optimum detection conditions will be discussed.

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[c] F. M. Schmidt, A. Foltynowicz, W. Ma, and O. Axner, J. Opt. Soc. Am. B 24, 1392 (2007).
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