SENSITIVE AND INSTANTANEOUS MOLECULAR DETECTION FROM BROADBAND CAVITY-ENHANCED DUAL COMB SPECTROSCOPY

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Recent experiments have demonstrated that the precisely spaced spectral lines of a laser frequency comb can be harnessed for new techniques of multi-heterodyne Fourier transform spectroscopy (also called dual-comb spectroscopy) of molecules. In one such experiment[a], an absorbing molecular gas was placed inside an optical cavity that is matched to the laser resonator so that it is resonant for each comb line. The sensitivity for weak absorption is much enhanced, as in cavity ring-down spectroscopy. The light transmitted by the cavity is superimposed on a second frequency comb with slightly different repetition frequency. A single fast photodetector then produces an output signal with a comb of radio frequencies due to interference between pairs of optical comb lines. The optical spectrum is thus effectively mapped into the radio frequency regime, where it becomes accessible to fast digital signal processing.
Experimental proof-of-principle is carried out in the near-infrared 1μm region. An Yb-doped fiber frequency comb is coherently coupled to a passive resonator with a finesse of 1200, resulting in an effective interaction length between the light and the gas enhanced to 880m. The weak $3\nu_1$ band of ammonia is rotationally resolved for the first time to our knowledge. Recording times of 18 μs are enough to span 220 cm^{-1} with a resolution of 0.15 cm^{-1}. The signal to noise ratio of 380 leads to a minimum-detectable-absorption coefficient α_{min} of 3×10^{-8}cm^{-1}.

[a]B. Bernhardt, A. Ozawa, P. Jacquet, M. Jacquey, Y. Kobayashi, T. Udem, R. Holzwarth, G. Guelachvili, T.W. Hänsch, N. Picqué, Cavity-enhanced dual-comb spectroscopy, Nature Photonics 4, 55-57 (2010)