BROADBAND HIGH-RESOLUTION SPECTROSCOPY WITH FABRY-PEROT QUANTUM CASCADE LASERS

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Simultaneous spectroscopic detection of large molecules with broad ro-vibrational spectra, and small molecules with well-resolved narrow spectral lines requires both broadband optical frequency coverage ($>$50 cm^{-1}) and high resolution ($<$0.01 cm^{-1}) to perform accurate spectral measurements. With the advent of room temperature, high power, continuous wave quantum cascade lasers (QCLs), high resolution mid-IR spectrometers for field applications became feasible. So far to address the broadband spectral coverage, external cavity (EC) QCLs with $>$100 cm^{-1}tuning ranges have been spectroscopic sources of choice in the mid-IR; however EC-QCLs are rather complex opto-mechanical systems, which are vibration-sensitive, and construction of robust transportable systems is difficult. In this work we present a new method of performing broadband mid-IR spectroscopy using two free-running Fabry-Perot (FP) QCLs to perform multi-heterodyne down-conversion of optical signals to RF domain. The sample transmission spectrum probed by one multi-mode FP-QCL is down-converted to the RF domain through an optical multi-heterodyne process using a second FP-QCL as the local oscillator[a]. Both a broadband multi-mode spectral measurement as well as high-resolution (15 MHz or 0.0005 cm^{-1}) absorption spectroscopy of NH_3 and N_2O are demonstrated and show potential for all-solid-state FP-laser-based spectrometers for chemical sensing.

[a] Y. Wang, M. G. Soskind, W. Wang, and G. Wysocki, "High-resolution multi-heterodyne spectroscopy based on Fabry-Perot quantum cascade lasers," Appl Phys Lett 104, 0311141-0311145 (2014)