ABSOLUTE FREQUENCY SCALE FOR HIGH-RESOLUTION QUANTUM CASCADE LASER DUAL-COMB SPECTROMETER

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Dual-comb spectroscopy with quantum cascade lasers is an inherently high-speed spectroscopic technique for the mid-infrared spectral region, as the sample is probed simultaneously at all the frequencies of the comb teeth. With typical beat note spacing of few MHz, the temporal resolution is of the order of microseconds and the spectral point spacing is typically 10 GHz. By interleaving several thousand spectra, the spectral point spacing is reduced to less than 10 MHz, suitable for spectroscopy of Doppler-broadened gases, within a measurement time of a few milliseconds. The above-mentioned interleaving is easily achieved by ramping the current of the lasers.

We seek the frequencies of every comb tooth at every instant of the ramp in order to produce a frequency axis for the interleaved spectra. We continuously measure the spectral point spacing of the interrogating comb (i.e., its repetition frequency) by pointing a directional microwave antenna at the laser and picking up the intermode beat, which oscillates at the repetition frequency. We further measure the optical frequency of one comb tooth by beating the comb with a frequency-locked distributed feedback laser, acting as the optical reference frequency. We test the accuracy of the computed frequency axis by measuring the well-known positions of the P and R lines of the ν_1 fundamental band of $\mathrm{N_2O}$ near 1300 $\mathrm{cm^{-1}}$. The spectral coverage is 1265-1305 $\mathrm{cm^{-1}}$, and the measurement (scan) duration is varied from 27 to 215 ms. We find that the frequency scale is accurate within 1 MHz.