DUAL-COMB UP-CONVERSION DETECTION OF FUNDAMENTAL MOLECULAR TRANSITIONS

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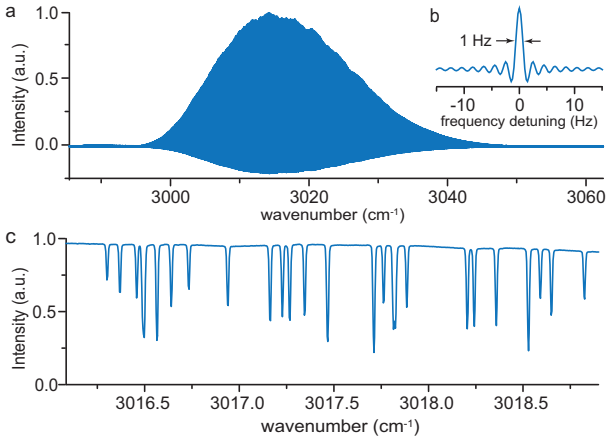

We present a new approach to mid-infrared dual-comb spectroscopy. Strong fundamental ro-vibrational transitions are interrogated in the mid-infrared 3-μm region, while the detection is performed in the near-infrared telecommunication region where sensitive opto-electronic tools are available. Using difference-frequency generation, a near-infrared comb is converted to the range of 2700-3400 cm^{-1}, where it interacts with the sample before being converted back to the telecommunication region. There, it beats with a second comb of slightly different line spacing for multiheterodyne detection. The broadband spectra obtained within arbitrarily long averaging time show resolved comb lines, a frequency scale calibrated within the accuracy of an atomic clock and a negligible contribution of the instrument line shape, as in previous reports using our recent scheme of feed-forward stabilization[a,b]. A spectrum (Fig. a, expanded view on a single comb line on the radio-frequency scale in Fig.b) in the region of the Q -branch of the ν_3 band of $^{12}CH_4$, is measured within 1000 s. The molecular profiles are sampled by the comb at a resolution of 3.3 10^{-3} cm^{-1}(Fig.c) across a total span of 50 cm^{-1}, with an average signal-to-noise ratio of 2540. Comparisons with direct mid-infrared detection will be discussed.

[a]Z. Chen, M. Yan, T. W. Hänsch, and N. Picqué, A phase-stable dual-comb interferometer, Nat Commun 9, 3035 (2018).

[b]Z. Chen, T. W. Hänsch, and N. Picqué, Mid-infrared feed-forward dual-comb spectroscopy, Proc Natl Acad Sci USA 116, 3454-3459 (2019).