Vibrational Dispersion Spectroscopy based on Phase-Shifting Spectral Interferometry

°(D)Wenqing Song[1], Daiki Okazaki[1], Ikki Morichika[1], and Satoshi Ashihara[1]
IIS, The Univ. of Tokyo[1]
E-mail: song-wq@iis.u-tokyo.ac.jp

The background-free spectroscopy (BFS) has proved to be a powerful tool for ultra-sensitivity gas sensing [1]. By canceling the background light using a stabilized destructive interferometer, the detection sensitivity increases with incident optical intensity, being unlimited by the dynamic range of the detector. However, BFS still suffers from the remaining background light because of the imperfect balance of the field unbalanced factor δ and the dispersion of the interferometer. In addition, the method requires an extra reference measurement to realize quantitative analysis.

To solve these issues, we develop a molecular dispersion spectroscopy method using the spectral interferometry and a Cr: ZnS mode-locked femtosecond laser [2]. The experimental setup is shown in Fig.1(a). The Cr: ZnS laser light goes through a Michelson interferometer with gas sample in one arm, and the interferogram is taken by the linear sensor detector after the monochromator during the scanning of one optical arm. The molecular dispersion information can be further retrieved from the interferogram. This method would have some important advantages. Firstly, this method can remove the background spectrum, including any unexpected spectral distortions to achieve highly sensitive detection as well as quantitative analysis. Secondly, careful calibrations on the precise time zero or balance of the transmission and dispersion between the two arms are unnecessary. Thirdly, both dispersive as well as absorptive spectra are acquired.

As for the results, Fig.1(b) show the raw interferograms with the central wavelength 2350 nm covering 30 nm wavelength range. By using the data neighbor to the π and 1/2π interference, the dispersion spectra of the molecules is successfully retrieved. Fig.1(c) shows the relative refractive index (n-1) for the first overtone of CO ro-vibrational lines by 3 shots with different central wavelength. In summary, we demonstrate a molecular dispersion spectroscopy method using the spectral interferometry, which effectively removes the background fringes, enables quantitative analysis, and requires no careful alignment and calibration on the interferometer.

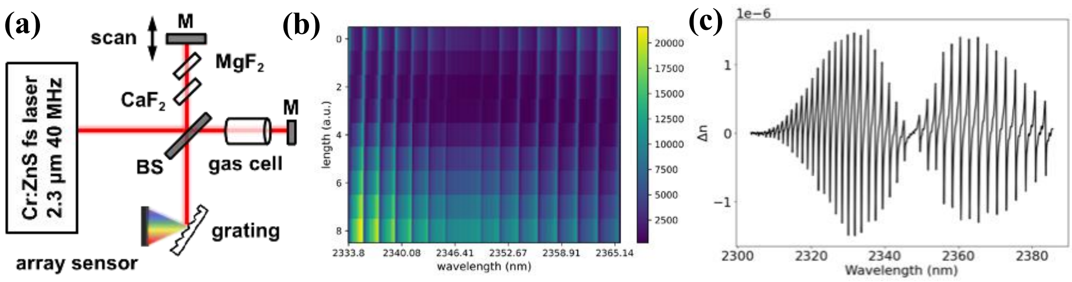

Fig.1(a) Experimental setup. BS: beamsplitter, M's: mirror. (b) The spectral interferograms with a 1/4 λ scan from π to 1/2π with CO gas sample. (c)The CO gas dispersion spectra retrieved from the interferograms.

[1] W. Song et.al., JSAP-OSA Joint Symposia, 13a_N404_6 (2021).
[2] D. Okazaki et al., Opt. Letter 44, 1750 (2019).