Performance Improvement of Miniature Stationary Fourier Transform Spectrometer using Resolution Enhancement Algorithm

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We recently prepared a small-size, low-power and stationary Fourier Transform spectrometer (FTS) using an electro-optic (EO) modulator that is a $LiNbO_3$ waveguide Mach-Zehnder interferometer (MZI) with push-pull electrodes [1-3]. Because of the intrinsic linear relationship between the modulating voltage and the optical path length difference (OPD) of the MZI, its interferogram as a plot of intensity against voltage was measured without any care for the voltage scanning to be linear or nonlinear. The FT processing of the interferogram results in a power distribution function with the half-wave voltage of the modulator, which is then transformed into the desired power spectrum by using the wavelength dependence of the half-wave voltage predetermined with the modulator. Such an EO-modulator based FTS operates in the wavelength range of 1100 nm to 1700 nm in which the single-mode condition is satisfied for the MZI. The FTS enables to accurately determine the laser wavelength and to measure absorption spectra of substances [2]. However, the FTS cannot provide subtle information on the analyte molecules due to its low resolution. Even in the case of using the endface reflection structure to increase the OPD of the MZI by two times, the spectrum resolution of the FTS is still insufficient [4].

In this work, an algorithm method was applied to the EO-modulator based FTS for further enhancement of its resolution. The algorithm was established based on the AR model combined with the singular value decomposition and the double linear prediction. The reasonable two-side extension of the measured interferogram data can be readily realized using the algorithm. The results indicate that the power spectrum reconstructed from the extended interferogram keeps good fidelity and its resolution can be more than 3 times higher than that from the original interferogram. The work demonstrated that the resolution enhancement algorithm is a simple and highly efficient approach to improve the performance of the EO-modulator based FTS.

References

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