

Free-Running Dual-Comb Spectroscopy Using Raman-Soliton Pulses from a Bidirectional Fiber Laser

○Takumi Takahoshi¹, Naoki Takeshi¹, Hisanari Takahashi², Toshiyuki Kawashima²,
Yoshiaki Nakajima¹

(1. Toho University, 2. Hamamatsu Photonics K.K.)

E-mail: yoshiaki.nakajima@sci.toho-u.ac.jp

In recent years, dual-comb spectroscopy (DCS) has attracted significant attention as a high-speed, high resolution, and broadband spectroscopic technique. In particular, dual-comb lasers that simultaneously generate two optical frequency combs from a single laser cavity, with slightly different repetition rates separated by Δf_{rep} , have been actively developed because they enable simplified DCS system without external phase-locking control[1]. We have previously reported the application of such light sources to gas spectroscopy[2].

In this study, we employ Raman soliton pulses generated through the soliton self-frequency shift (SSFS)[3] to realize wavelength-tunable DCS. By tuning a narrowband dual-comb spectrum over a wide spectral range, the SNR per comb mode can be enhanced, thereby reducing the coherent averaging time required for broadband measurements. Fig. 1(a) shows the experimental setup. The outputs of a bidirectional dual-comb fiber laser were amplified using an erbium-doped fiber amplifier (EDFA) and subsequently launched into a 10-m-long Raman fiber. As the EDFA output power increased, wavelength shifts toward the longer wavelengths were observed at both the clockwise (CW) and counterclockwise (CCW) output ports, as shown in Fig. 1(b). By tuning both outputs to 1660 nm, we successfully obtained an interferogram and measured the transmittance spectrum of methane, as shown in Fig. 1(c). The measured spectrum was in good agreement with the HITRAN simulation.

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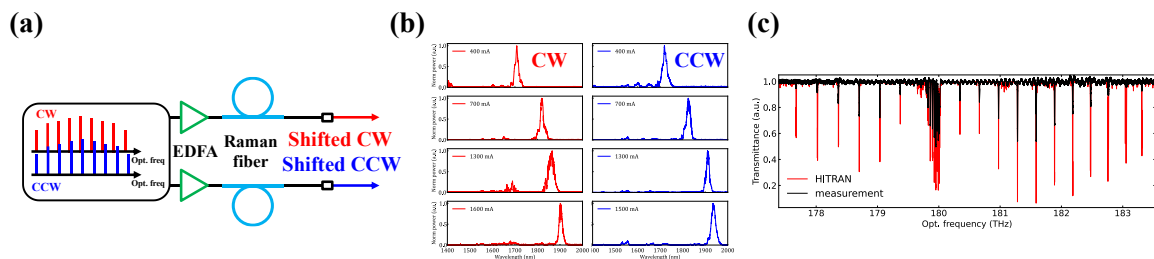


Fig. 1(a) Experimental setup. (b) Spectra of the CW and CCW outputs redshifted by the SSFS. (c) Methane transmittance spectrum measured by DCS using Raman soliton pulses at 1660 nm (black), compared with the HITRAN spectrum (red).

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