Phase locking of two-color Electro-optic frequency combs generated with common modulators for coherent synthesis

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Benefit from the wide tunability and tens of GHz high repetition rate, electro-optic (EO) combs have shown great potential in many applications, like optical waveform synthesis, multiheterodyne optical detection, pulse-to-pulse interference-based distance measurement, etc.[1-2] Typically, an EO comb is generated through modulating one CW laser with cascaded EO intensity modulators and EO phase modulators. In this work, we modulate two CW lasers at distinct wavelengths via common EO modulators, resulting in a two-color EO comb with high relative stability due to common RF noise suppression, which opens up application with great flexibility and controllability. Here the beat signal between two-color EO comb is detected and phase locked to a low noise radio frequency (RF) reference to achieve coherent synthesis.

Our experimental setup is shown in Fig. 1(a). Two CW lasers centered at 1550.1 nm and 1552.1 nm are modulated by a series of the same EO modulators, including two intensity modulators and three phase modulators. As a result, two EO combs with partly overlapped spectra are generated, named two-color EO comb. Fig. 1(b) shows the optical spectrum of two-color EO comb. The two-color EO comb is amplified to 80 mW by an EDFA and filtered by a bandpass filter (BPF). Then, a beat signal between the two-color EO comb is detected. The phase noise of this beat signal reflects the relative noise of the overlapped comb lines. The beat signal is frequency divided by a factor of 440 and phase locked to a low-noise RF reference via current feedback to CW 2. After stabilization, stability of f_{beat} is at 10^{-15} level in 1 s gate time. The Allan deviation of f_{beat} is shown in Fig. 1(c). In this way, the relative phase noise of two combs is suppressed, leading to a coherently synthesized two-color EO comb. The demonstrated two-color EO comb shows potential in applications such as distance measurement, optical waveform synthesis, and so on.

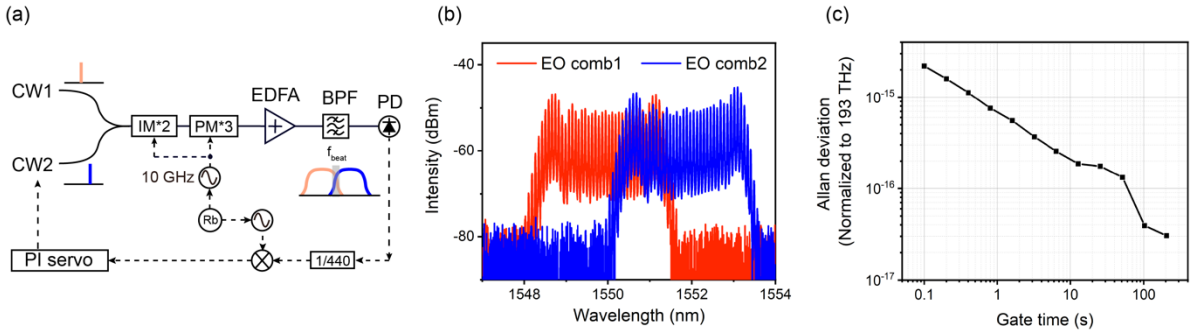

Fig.1 (a): experimental setup. (b): spectrum of two-color EO comb before and after BPF. (c): Allan deviation of f_{beat}.

[1] Carlson D. R, Hickstein D. D, Zhang W, et al. Science, 2018, 361(6409): 1358-1363.

[2] David R. Carlson, Daniel D. Hickstein, and Scott B. Papp, Opt. Express 28, 29148-29154 (2020)