Passively Phase-Locked Fiber Frequency Comb

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In the last decade optical frequency combs became the instrument of choice for optical precision metrology[1,2]. For the majority of these applications locking of the carrier envelope offset frequency (f_{CEO}) and the repetition rate (f_{Rep}) is required. Recently we developed a technique for passive f_{CEO} stabilization[3] of an Er:fiber laser. Employing this approach we demonstrate an Er:fiber system locked to an RF reference and passively stabilized CEP at the full repetition rate of 100 MHz. Such a passively stabilized comb is intrinsically robust and compact owing to an all-fiber oscillator design consisting only of polarization-maintaining fibers while omitting free space components. In our approach, the output of the Er:fiber laser is focused into a highly nonlinear germano-silicate bulk fiber (HNF) to generate a coherent octave-spanning supercontinuum spectrum[4]. The generation of the phase-locked pulses is obtained via an efficient intra-pulse difference frequency generation (DFG) in a periodically poled lithium niobate crystal (PPLN). This phase-stable pulse train, centered at 1550 nm with a spectral width of 100 nm, serves as a seed for a two-branch multi-stage Er:fiber-amplifier. One branch is used to monitor the phase noise of the frequency comb in different parts of the spectrum via heterodyning with various single-frequency lasers (Fig. 1a). The linewidth of the stabilized system at a center wavelength of 1550 nm is measured to sub-100 kHz. For this measurement, the repetition rate of the laser is locked to an RF reference at a frequency of 100 MHz via control of the pump diode current. Locking is achieved with a standard deviation of 2.3 mHz at an interrogation time of 250 ms (Fig. 1b). This performance is limited by the stability of the RF reference itself. In a second branch, a single-pass amplifier boosts the average power up to 600 mW. Here advanced stabilization techniques on various optical frequency references are currently being investigated. While the linewidth of our compact, all-fiber and passively-stabilized comb is already narrow, current efforts are underway to exploit active stabilization to further improve this performance benchmark.

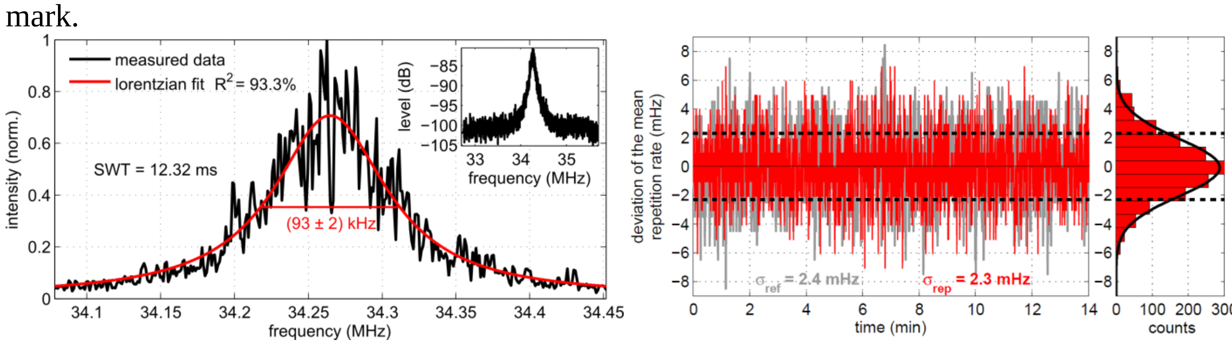

Fig. 1: a) Heterodyne beat of the passive phase stable frequency comb with a narrow linewidth laser; b) long-term stability of the repetition rate of the comb (red), limited by the RF reference (grey).

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