Coupled Optoelectronic Oscillators: Applications to Low-Jitter Pulse Generation and Optical-Microwave Frequency Stability Transfer

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Optoelectronic oscillators have been demonstrated to generate ultra-low phase noise microwaves at 10 GHz and beyond [1]. Such microwave sources are of great interested to the telecommunication and radar applications. On the other hand, actively mode-locked lasers (MLL) have been shown to produce low-jitter picosecond pulses at repetition rates at 10 GHz and higher [2]. The jitters were mostly limited by the mode-locking RF source (typically electronic synthesizers). It is possible to combine the two technologies for ultra-low jitter picosecond pulse generation. For that purpose, coupled optoelectronic oscillators (COEO) have been proposed and demonstrated [3]. In such a system, the optical oscillator of the mode-locked laser and the microwave oscillator of the OEO are coupled through a common Mach-Zehnder intensity modulator. Thus, the drive for the MLL is generated from the OEO and the energy of the OEO is derived from the beat-note of the mode-locked laser, forcing the repetition rate of the MLL and OEO oscillation frequency to be exactly the same. The pulse jitter of a COEO at 10 GHz is expected to reach below 10 fs. In this paper, we will describe our coupled optoelectronic oscillator using erbium-doped fiber laser system and show the latest experimental results.

We will also discuss the possibility of using similar COEO systems for optical-microwave frequency stability transfer. The setup resembles the optical comb regeneration using femtosecond pulse lasers [4]. It has been shown clearly that the optical carrier frequency of the MML and its repetition rate have a definite relationship through the laser cavity length, if the intracavity dispersion can be well controlled. In a COEO, in addition, the repetition rate is also over-constrained by the high-Q OEO cavity. The strong coupling of the two oscillators together with proper dispersion compensation in the fiber laser offers the possibility of high-stability between optical carrier and microwave frequency without active intracavity dispersion control. Furthermore, we will investigate the role of a soliton laser in the intracavity dispersion control.

References:

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