Sub-100 attosecond timing jitter from low-noise passively mode-locked solid-state laser

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The relative timing jitter between the pulse trains of two identical passively modelocked diode-pumped solid-state lasers (DPSSLs) has been measured using a balanced optical cross-correlator as timing discriminator. The lasers, operating at C-band telecom wavelength, emit a train of 150-fs soliton pulses at a repetition rate of 100 MHz. Single-laser timing jitter values as low as 83 attoseconds were calculated (integrated from 10 kHz to 50 MHz), assuming identical behaviors of the two lasers and no timing correlations above 10 kHz[1]. The relative intensity noise spectrum (RIN) of the lasers was also measured. Integrating it over the same frequency range (10 kHz to 50 MHz), a very low value of $7.3 \cdot 10^{-9}$ is obtained.

A theoretical timing jitter spectrum was calculated considering the following contributions: the quantum noise on the pulse position, the Gordon–Haus effect, the coupling of intensity noise to timing noise via the Kramer–Kronig relation and the self-steepening effect. It was found that although the measured integrated jitter is quite low, it is still significantly above the theoretical limit in the considered frequency span. The possible technical origin of this exceeding jitter and measures to reduce it will be discussed.

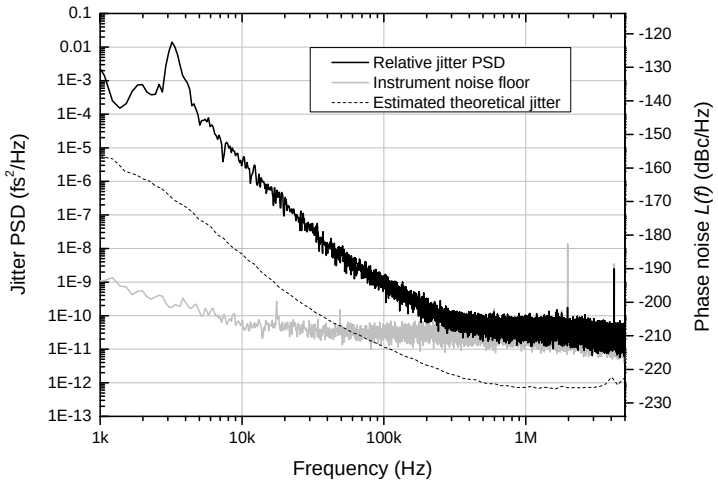

Figure 1: Measured relative timing jitter spectrum (black curve) and estimated theoretical value (dotted curve). The instrument noise floor of the measurement is also indicated (gray curve). The phase noise is extrapolated from the timing jitter to a carrier frequency of 10 GHz.

[1] E. Portuondo-Campa, R. Paschotta, S. Lecomte, "Sub-100 attosecond timing jitter from low-noise passively mode-locked solid-state laser at telecom wavelength", Optics Letters, 38 (15), August 2013, 2650-2653