Long-term, real-time correction of carrier-envelope phase jitter

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Stabilization of the carrier-envelope (CE) phase of optical pulses can be achieved via two main approaches: the feed-back method (D. J. Jones et al., *Science*, **288**, 2000, pp. 635-639, R. Holzwarth et al., *Physical Review Letters*, **85**, 2000, pp. 2264-2267) and the feed-forward method (S. Koke et al., *Nature Photonics*, **4**, 2010, pp. 462-465). Feed-forward stabilization realized through shifting of the entire optical comb to zero CE offset frequency by an acousto-optic frequency shifter (AOFS) has proven to be superior to feed-back stabilization in terms of effective servo bandwidth and demonstrated residual CE phase jitters down to 10 mrad. However, there are various limitations of the originally proposed scheme. First, a slow feed-back loop is still needed to bring the CE offset beatnote into the limited spectral range of the AOFS and/or the AOFS driver circuitry. Second, the diffracted beam exhibits CE offset frequency dependent angular dispersion and pointing direction. Third, the acoustic propagation delay in the modulator crystal from the transducer to the interaction volume is several hundred nanoseconds limiting the effective servo bandwidth to a few 100 kHz, which is insufficient for extremely noisy lasers, such as certain fiber lasers.

The first two disadvantages have recently been removed for optical amplifiers by synthesizing a narrow-band acoustic frequency comb out of the measured CE offset beatnote and the amplifier repetition rate (B. Borchers et al., *Optics Letters*, **39**, 2014, pp. 544-547). With the scheme, the requirement of keeping the CE offset beatnote within the range of the AOFS could be dropped and long-term, fully feed-forward operation became possible. However, the approach relied on a narrow bandpass filter in the signal chain of the AOFS driver circuit with a group delay comparable to the acoustic travel time leading to further reduction in the effective correction bandwidth.

In the talk, an improved version of the feed-forward stabilization scheme based on acoustic frequency combs is presented that overcomes the bandwidth limitations caused by both the acoustic propagation delay inside the AOFS and the narrow RF bandpass filter in the electronic circuitry. The modified scheme enables an order-of-magnitude increase in the effective servo bandwidth, while at the same time stays reasonably long-term stable.