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Active pump-seed-pulse synchronization for OPCPA with sub-2-fs residual timing jitter: erratum

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Abstract: In the original manuscript, a residual RMS timing jitter below 2 fs between pump and seed pulses in the stabilized case was claimed. Following a reevaluation of the data, this was underestimated. Due to a rounding error in the calibration routine, a miscalculated calibration factor was extracted. By using a higher precision, the updated residual timing jitter amounts to 2.76 fs, or sub-3 fs. In this erratum, the calibration routine is briefly reviewed and Fig. 4, which presents the timing jitter in the stabilized and unstabilized case, is updated. All other results remain unaffected.

OCIS codes: (140.3425) Laser stabilization; (140.7090) Ultrafast lasers; (190.4970) Parametric oscillators and amplifiers.

References and links

1. S. Prinz, M. Häfner, M. Schultze, C. Y. Teisset, R. Bessing, K. Michel, R. Kienberger, and T. Metzger, "Active pump-seed-pulse synchronization for OPCPA with sub-2-fs residual timing jitter," Opt. Express **22**(25), 31050–31056 (2014).

Following the data presented in Fig. 4 of Ref [1], active stabilization of the pulse arrival times with a residual RMS timing jitter of $\sigma < 2$ fs is claimed, corresponding to less than 0.2% of the pump pulse duration. This value heavily depends on the system calibration, which is reviewed in this erratum.

To obtain a value for the timing jitter in fs, the relationship between the detected spatial offset on the position sensitive detector (PSD) and the timing delay must be calibrated. In general, the system is calibrated by introducing an artificial delay Δt and measuring the associated spatial offset Δx on the PSD. The calibration factor K in the vicinity of the current position is then given by

$$K = \frac{\Delta t}{\Delta x}. \quad (1)$$

Because the system behavior is not linear throughout the whole measurement range, a calibration has to be performed for every value of x where a precise measurement is required. In the stabilized case however, only the timing jitter in the setpoint $x = 0$ mm (center of the PSD) is of interest.

Because of the ongoing delay fluctuations, which superimpose any artificially introduced pulse delay, the calibration procedure is challenging. On that account, large calibration delay steps compared to the short-term timing jitter of a few 100 fs are chosen to minimize the error. In addition, calibration was performed after thermal stabilization of pump and seed laser, where slow thermal drifts are negligible.

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Figure 1 presents the calibration of the synchronization system. A total delay range of ± 3 ps around x = 0 mm has been measured by moving the integrated delay stage in steps of 100 µm, which corresponds to an artificial delay of (2*100 µm)/c = 667 fs per step. The corresponding position on the PSD is determined as the average from a series of 10000 consecutive samples. A second order polynomial least squares fit is applied to the data. No weighting of data points has been performed, which is justified by the constant signal-to-noise ratio throughout the calibration range. The tangential slope of the fit at the setpoint yields a calibration factor of

$$K = 5.8211 \pm 0.086 \, \frac{\text{ps}}{\text{mm}}.$$

The uncertainty of 1.48% is given by the standard error of the fitted first order coefficient.

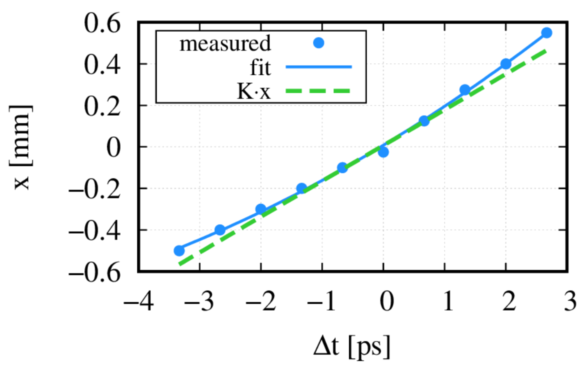

Fig. 1. System calibration curve. A second order polynomial fit is applied to the measurement. The tangential slope at x = 0 mm yields the calibration factor K.

Applying this calibration factor to the raw data of the short-term timing jitter results in an updated residual RMS timing jitter of 2.76 ± 0.04 fs in a bandwidth from 0.1 Hz to 1 kHz. This equals ~0.23% of the pump pulse duration and is sufficient to guarantee stable OPCPA operation, as claimed in the original manuscript. Figure 2 presents the updated graph of the short-term timing jitter (Fig. 4 in Ref [1]).

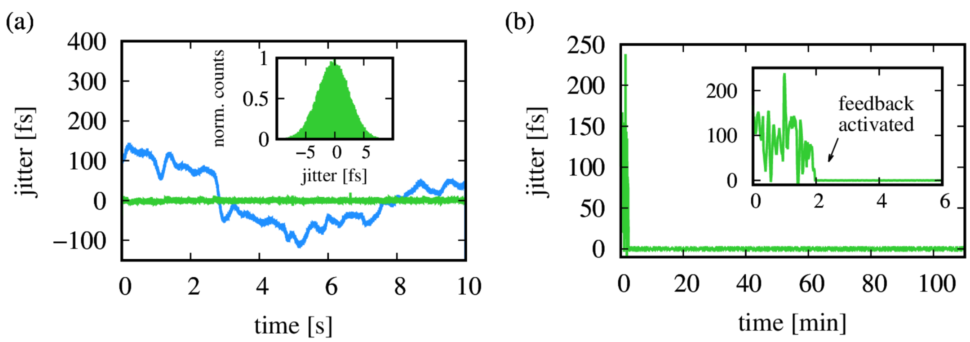

Fig. 2. (a) Short-term timing jitter unsynchronized (blue) and with active synchronization (green). The RMS timing jitter in the stabilized case is reduced to σ < 3 fs. The inset shows a histogram of the measured timing jitter values. (b) Long-term measurement of the timing delay between the pump and seed pulses. Inset: Activation of the stabilization after 2 min.