ATTOSECOND TIMING DISTRIBUTION

Ultra-stable distribution of timing signals plays a key role in many scientific experiments and research facilities like free electrons lasers or radio-telescope arrays. Timing distribution via optical fiber is convenient and it enables connection of very distant devices separated by distances of hundred meters. Such optical links achieve distribution of RF signals with sub-femtosecond synchronization-level over years.

We describe here how two MENHIR-1550 lasers can be synchronized to each other to achieve high precision in timing distribution by comparing them with a balanced optical cross-correlator (BOC) from Cycle GmbH.

Menhir Photonics' product strengths

Excellent passive repetition rate stability

Lowest timing-jitter on the market

Ultra-high reliability and long lifetime

Application use case

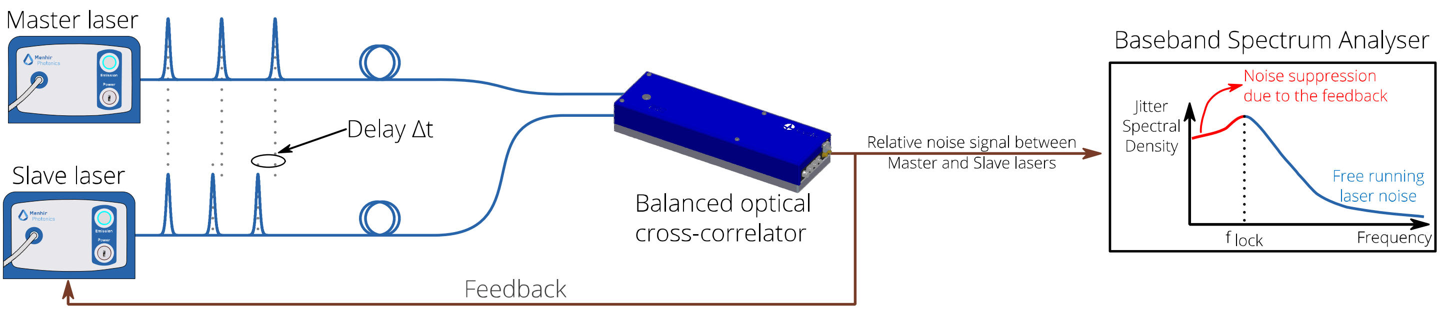

Figure 1 — Synchronization at the attosecond level of the repetition rate of two MENHIR-1550 lasers using a BOC from Cycle GmbH.

Short term stability

Using the setup depicted in Figure 1, we synchronize the repetition rate of the slave laser to the master laser to obtain the record-level of < 0.12 fs of residual timing-jitter on the frequency range of [1 Hz – 1 MHz]. The MENHIR-1550 laser has slow and fast actuators for repetition rate adjustment. Only a feedback on the fast actuator of the slave laser was used in this experiment to achieve active stabilization (15 hours test).

Figure 2 shows that up to 100 kHz of feedback bandwidth can be achieved. This demonstrates that implementation of two synchronized MENHIR-1550 lasers enables an optical timing-distribution solution with new and unprecedented level of synchronization.

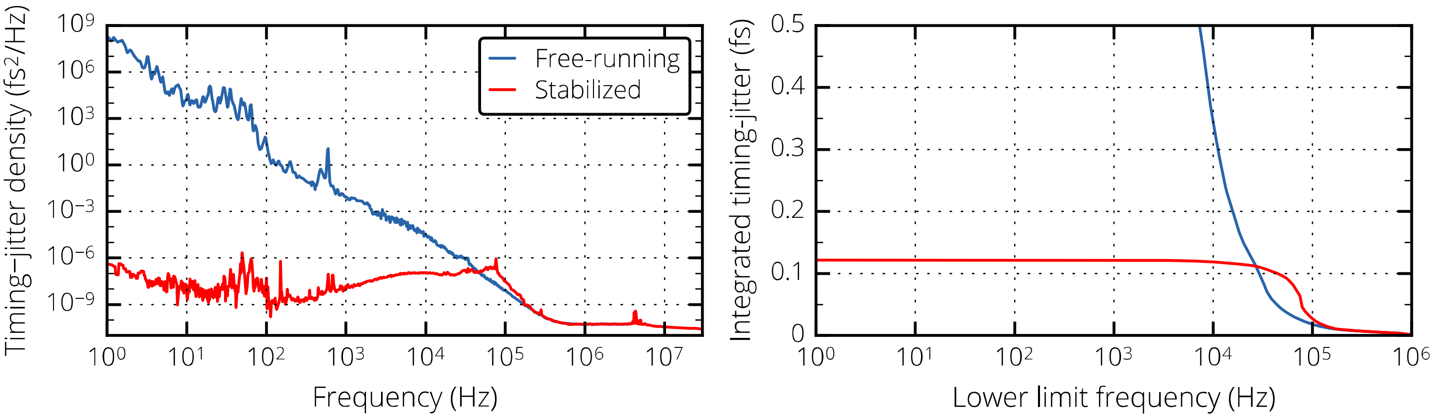

Figure 2 — Timing-jitter density (left) and integrated timing-jitter (right) between the master and the slave laser in free-running (blue) and stabilized (red) conditions. In the range [1 kHz – 1 MHz], relative integrated timing-jitter of 2.64 fs and 0.12 fs are achieved, respectively.

Long term stability between the two lasers

Thanks to the passive stability of the MENHIR-1550 lasers, a residual timing-jitter error of less than 50 as was achieved during the 15 hours of the test. During the locking, the fast piezo received a maximal voltage difference of less than 10 V (relative to a full range of 0 – 100 V), corresponding to less than 70 Hz of compensation (see Figure 3). In the experiment the coarse piezo voltage was held constant. This demonstrates the high passive stability of both lasers.

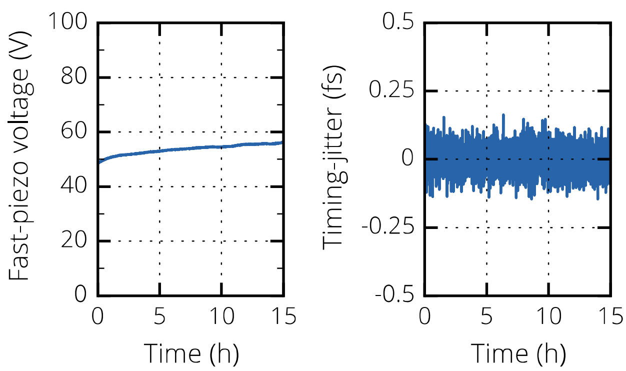

Figure 3 — Passive stability of both lasers: Evolution of the fast-piezo compensation voltage (left) and recorded in-loop timing-jitter (right) along 15 hours. RMS timing-jitter is 41 as.

References

1. M. Xin, K. Şafak, M. Y. Peng, P. T. Callahan, A. Kalaydzhyan, W. Wang, K. Shtyrkova, Q. Zhang, S.-H. Chia, B. Jones, T. Hawthorne, P. Battle, O. D. Mücke, T. Roberts, F. X. Kärtner, *Sub-femtosecond precision timing synchronization systems*, Nucl. Instrum. Meth. A **907**, 169 (2018)
2. J.-D. Deschênes, L. C. Sinclair, F. R. Giorgetta, W. C. Swann, E. Baumann, H. Bergeron, M. Cermak, I. Coddington, N. R. Newbury, *Synchronization of Distant Optical Clocks at the Femtosecond Level*, Phys. Rev. X **6**, 021016 (2016)

Related product: MENHIR-1550 at 216.667 MHz

Repetition rate	216.667 MHz (other values available)
Average power	> 100 mW without amplifier
Central wavelength	1555 +/- 10 nm
Spectral bandwidth at -3 dB	> 10 nm (i.e. sub-250 fs pulses)