Optical synchronization of ultrafast lasers for attosecond-level timing distribution

Ultra-stable distribution of timing signals is of high importance in academic research infrastructures such as particle accelerators and for a growing number of research facilities. Newest generation high brightness ultrafast x-ray sources driven by free electron lasers have typically sub-10 fs requirements on the distribution of RF signals to accelerator components and laser systems. In this document, we explain and detail how two ultrafast lasers can be synchronised to each other to achieve such precision.

Schematic

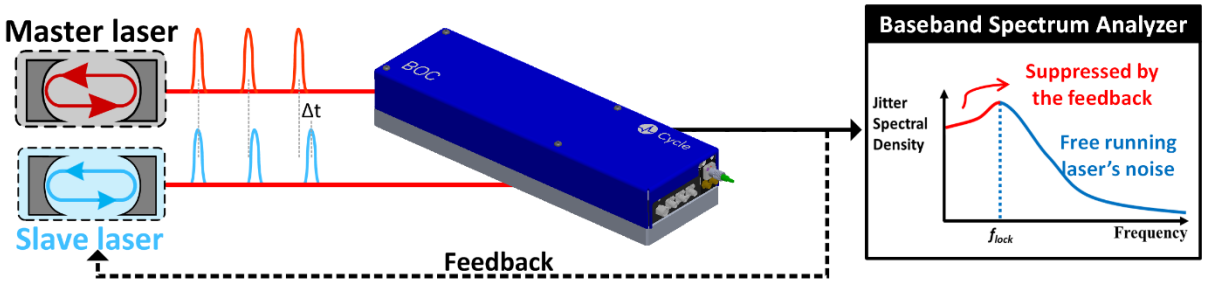
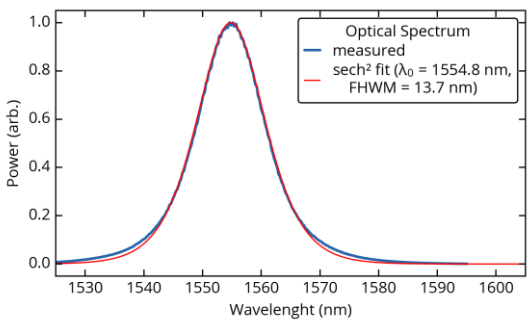


Figure 1. Synchronization of the repetition rates of two ultrafast lasers using a balanced optical cross-correlator.

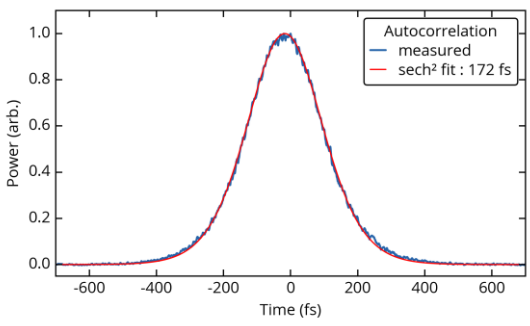
Parameters of the Menhir Photonics lasers

Main laser parameters	Value
Repetition rate	216 MHz
Average power	> 100 mW without amplifier
Center wavelength	1555 +/- 5 nm
Spectral bandwidth at – 3dB	> 12 nm (i.e. sub-200 fs)

Laser spectrum – Linear. Scale

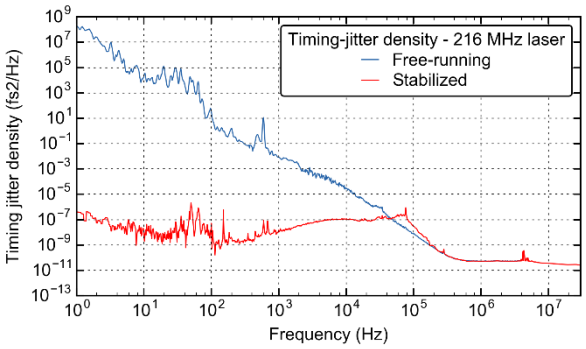


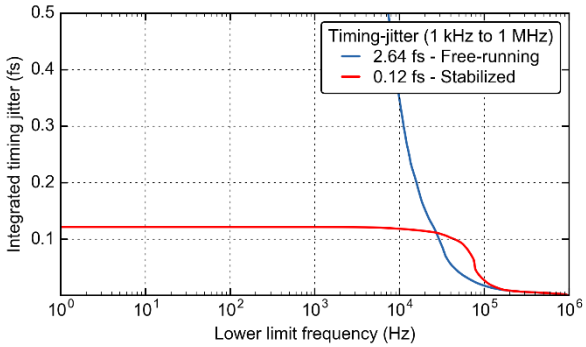
Laser Autocorrelation



In-loop stabilization using balanced optical cross-correlator

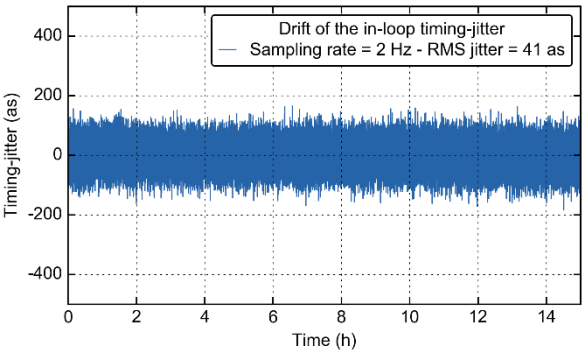
Using the setup depicted in Figure 1, the two lasers could be stabilized to each other to record level, achieving < 120 as of residual timing-jitter on [1 Hz – 1 MHz] between the two lasers. The laser systems were stabilized to each other with the fast piezo actuator of the slave laser, showing that > 100 kHz of feedback bandwidth could be achieved.

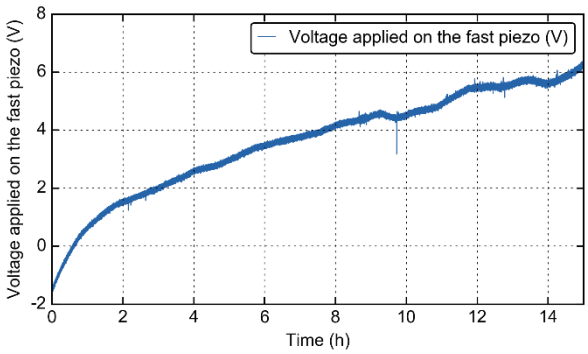




Long-term stability

Thanks to the extreme stability of the lasers, the lock between both systems could be easily maintain for 15 h with an in-loop timing-jitter drift < 50 as. It needs to be noted that during this 15 h lock, the feedback voltage sent to the fast piezo of the slave laser changed by less than 10 V, corresponding to less than 70 Hz of required compensation between both lasers, showing the passive stability of the systems.





Others

Find more videos and tutorial on these experiments in our Youtube pages (Menhir Photonics AG or Cycles GmbH). For further information, please contact Florian Emaury at contact@menhir-photonics.com