Optical Cross-correlation

The ideal solution for synchronizing ultra-short pulsed laser sources

Content

Synchronizing two laser sources or measuring the timing jitter of a low-noise laser requires a high-precision timing detector. In this case, using a photodetector would be one obvious approach. However, for high precision measurements in the femtosecond regime, simple photodetection is too slow. With its balanced optical cross-correlator (BOC), Cycle provides a timing detector with femtosecond timing resolution, high stability, and robustness. What is the principle of timing detection with a BOC?

To compare the phase position of two pulsed laser beams with high precision, it is not easy to directly measure the relative timing jitter. You need to find a way to amplify the jitter signal, measure the difference, and then reconstruct the original timing from the amplified difference.

Cycle's BOC follows such an approach by using a non-linear crystal for the signal amplification. The crystal has two unique properties: On the one hand, two photons can be combined to generate a new photon at their sum frequency. On the other hand, two orthogonal polarized laser beams move with different group velocities through the crystal.

The two laser beams enter orthogonally polarized in the BOC and then pass a non-linear crystal in a double-pass configuration. In the crystal, different amounts of sum-frequency light are generated on the forward and reverse pass. A balanced photodetector measures the difference in sum-frequency power as a voltage signal, which is proportional to the timing jitter between the two pulses.

Selecting the correct crystal configuration, it is also possible to detect the timing jitter of two optical pulse trains with different center wavelengths. The so-called two-color balanced optical cross-correlator (TCBOC) and the BOC are ideal solutions for synchronizing ultra-short-pulsed laser sources in demanding measurements or high-end timing applications.

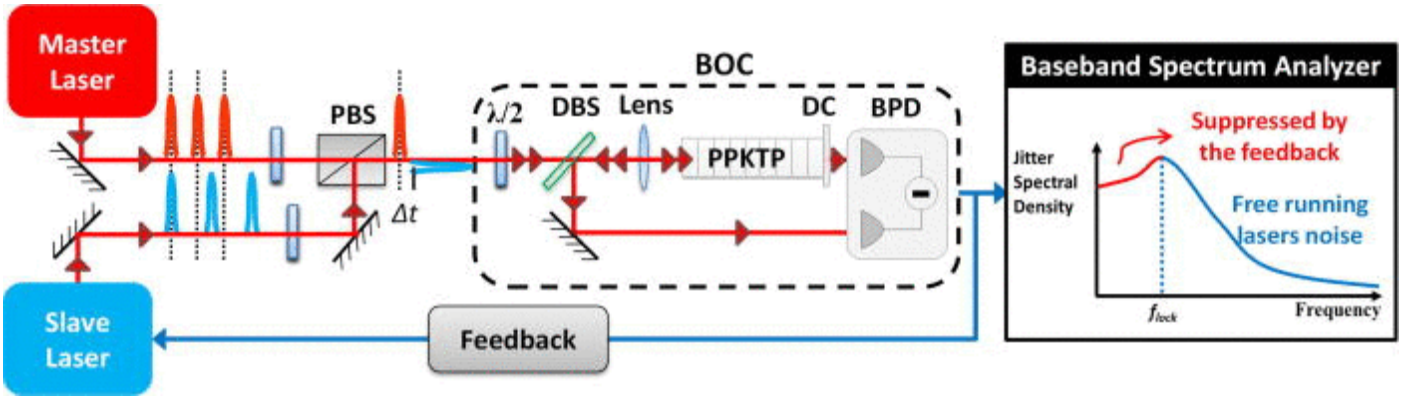

Figure 1 – Experimental setup for timing jitter characterization using a BOC (Shafak et al. (2015))

References

1. K. Şafak, M. Xin, P.T. Callahan, M.Y. Peng and F.X. Kärtner, “All fiber-coupled, long-term stable timing distribution for free-electron lasers with few-femtosecond jitter,” Structural Dynamics 2, 041715 (2015)
2. J. Kim, J. Chen, J. Cox and F.X. Kärtner, “Attosecond-resolution timing jitter characterization of free-running mode-locked lasers,” Opt. Lett. 32, 3519–3521 (2007)

Related Products

BOC

Lowest noise optical synchronization of two femtosecond lasers at the same wavelength

TCBOC

Lowest noise optical synchronization of two femtosecond lasers with different center wavelengths

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