# Carrier-envelope phase control and stabilization by an acousto-optic programmable dispersive filter

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**Abstract:** We demonstrate arbitrary control of the carrier-envelope (CE) phase using an acousto-optic programmable dispersive filter (AOPDF) inserted in a chirped-pulse amplification (CPA) Ti:S laser. We also demonstrate, for the first time, closed-loop CEP stabilization using an AOPDF to correct for the CEP slow drifts.

In chirped-pulse amplification (CPA) lasers, the CE phase can be locked for tens of minutes by stabilizing the CE phase offset of the oscillator. However, amplifying stabilized pulses raises some new issues. First, all the optically dispersive components of the amplification chain (crystals, stretcher, compressors…) add some offset on the CE phase. Second, thermal effects and/or acoustic vibrations induce mechanical drifts causing dispersion fluctuations and, eventually, CE phase drifts. Since the CE phase value must be kept constant on target, a slow-loop stabilization of backend CE phase is most often required, to ensure reproducible results but also to give control over the CE phase of the amplified pulses. To date several mechanisms have been proposed and demonstrated to control the CE phase: modulation of the power of the pump laser at the oscillator level, insertion of glass wedges plates, control of the grating separation in grating-based compressors… These devices are all based on dispersion modulation which might change the pulse duration, sometime use moving parts and do not allow shot-to-shot arbitrary control of the CE phase at kHz repetition rates.

In this paper, we demonstrate arbitrary control of the CE phase using an acousto-optic programmable dispersive filter. Opposite to other devices, the CE phase control is completely decoupled from dispersion control (though is allows phase and amplitude control of the spectral phase), does not involve moving parts and allows arbitrary but precise and quantitative shot-to-shot CE phase offsets. In the low-jitter configuration, the electronic generator of the AOPDF is able to control the CE phase of the acoustic wave within <40 mrad (value limited by our measurement device). Since the acoustic CE phase is transferred on the optical CE phase through the acousto-optic interaction, the CE phase of the diffracted pulse can be changed with respect to the CEP of the input pulse by an arbitrary amount within 40 mrad. As a proof of control, Fig. 1 shows the effects of successive CE phase jumps applied by the AOPDF. These phase steps were performed at a low repetition rate, corresponding to the repetition rate of the CE phase measurement device (f-2f interferometer), i.e., not limited by the refresh rate of the AOPDF.

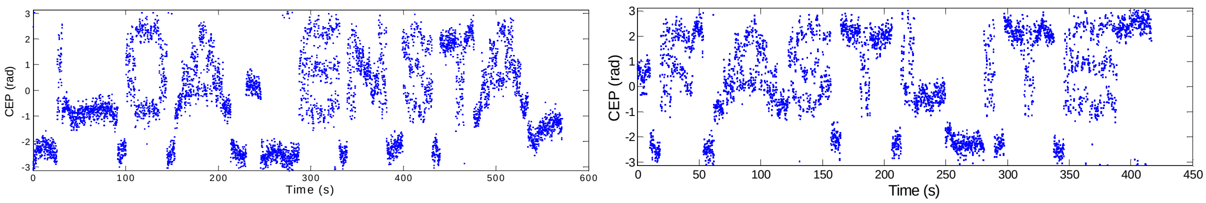


Fig.1 Demonstration of CEP control.

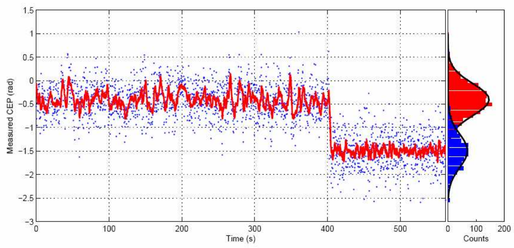


Fig.1: CE phase stabilization. Left part (<400s): open-loop. Right part (>400s): closed-loop.

Closed loop control was implemented using a f-2f interferometer and CE phase stabilization with repetition rate >15Hz were demonstrated.