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Stable platform for phase-modulation of seed lasers facilitating all-XUV coherent nonlinear time-domain spectroscopy

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Coherent time-resolved spectroscopy is a powerful tool to study ultrafast dynamics in complex systems. Extending this to the XUV spectral region is on the frontier of nonlinear spectroscopy. However, demands on interferometric stability increase when going to short wavelengths and advanced pulse manipulation in the XUV is challenging. In seeded free electron lasers (FEL) the emitted XUV pulses inherit the coherence properties of the seed pulses [1]. This motivates our approach based on performing acousto-optical phase modulation (PM) on the seed laser with subsequent seeding of the FEL and lock-in detection at the harmonics of the seed modulation [2]. In this way demands on interferometric stability are efficiently decoupled from the laser wavelength, and XUV signals are isolated and amplified [3, 4].
We present a compact, stable and transportable platform specifically designed to perform PM on 266 nm seed laser pulses. All optics are tailored to withstand high peak intensities and dispersion is reduced to a minimum. High stability of the platform and the sensitivity of the PM approach was verified observing UV quantum beats (268 nm) in a low-density sodium beam (1.5x10⁸ cm⁻³), detecting photoions with a time-of-flight mass spectrometer at a laser repetition rate of 50 Hz. The platform has been implemented in the FERMI FEL seed laser test beamline for characterization.

[1] Gauthier et al., PRL 116, 024801 (2016)
[2] Bruder et al., Opt. Express 25, 5302-5315 (2017)
[3] Bruder et al., PRA 92, 053412 (2015)
[4] Bruder et al., Opt. Lett., OL 43, 875 (2018)

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