19p-C2-8

Long-term passive stabilization of the carrier-envelope phase of infrared few-cycle pulses from an optical parametric chirped-pulse amplifier

ISSP - University of Tokyo,　°Henning Geiseler, Nobuhisa Ishii, Keisuke Kaneshima, Teruto Kanai, Jiro Itatani

E-mail: geiseler@issp.u-tokyo.ac.jp

Control over the carrier-envelope phase (CEP) of ultrashort optical pulses proves essential at the forefront of stong-field physics, as light-matter interaction is mainly dictated by the electric field, and with pulses comprising only a few optical cycles, the actual waveform strongly depends on the CEP. With a few-cycle pulse, the motion of electrons in light-matter interaction can be steered with high accuracy, but many experimental techniques in strong-field physics rely on repeated iterations with identical parameters. A light source that provides long-term stability of the CEP is therefore crucial for these experiments.

Various concepts have been devised to actively stabilize the CEP in amplified few-cycle pulses, and demonstrated to provide stable operation on a time scale of typically several minutes to a few hours. We show that in the case of our passively stabilized optical parametric chirped-pulse amplifier [1], control of the environmental parameters suffices to stabilize the CEP for almost two days of uninterrupted operation.

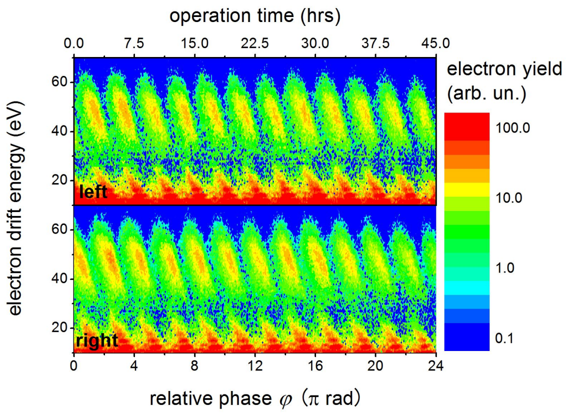

Fig.1: Electron spectra in opposing directions from xenon as a function of the phase φ.

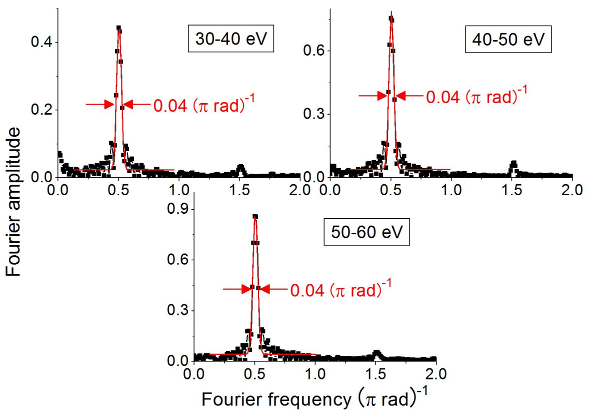

Fig.2: Fourier transforms of the electron yield as function of φ, for 3 separate energy regions.

Figure 1 shows electron spectra from ionization of xenon along the polarization axis, while the phase φ is scanned in steps of 0.05π rad over the duration of 45 hours with a period of 3.75 hours. Fourier transforms of the data in different energy ranges in Fig. 2 show that the electron spectra follow that periodicity within an accuracy of 250 mrad, which to the best of our knowledge is the longest demonstrated CEP-stable operation of an amplified few-cycle source to date. Crucial aspects to achieve this kind of stability are constant environmental parameters in the laboratory, keeping the temperature within (24.0 ± 0.1)°C, and a layout minimizing vibrations and mechanical drifts.

[1] N. Ishii *et al.*, Opt. Lett. **37**, 4182 (2012)

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