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先端光量子科学アライアンス談話会

光量子科学研究センターセミナー

東京大学 G-COE プログラム
-未来を拓く物理科学結集教育研究拠点-

Attosecond physics – at a nanoscale metal tip

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日　時　：　平成 25 年 1 月 7 日(月) 13:30-15:00

場　所　：　東京大学理学部 1 号館 2 階 201A 号室

Abstract

Attosecond physics is based on the control of electronic matter waves by few-cycle laser pulses. Within a single optical cycle, an electron can be driven away from the parent matter and return to its origin when the laser field flips sign. There, it can recombine and radiate away the energy it has gained in the laser field; this is the basis of high harmonic and attosecond pulse generation. Alternatively, the electron can re-scatter at the parent matter elastically, only to pick up more momentum in the laser field and escape. All this is well-known from and at atoms and molecules in the gas phase. We have observed these effects at a nanoscale metal tip. We observe above-threshold photoemission (1), re-collision and elastic scattering of the electron at the metal tip (2), and electronic matter wave interference, which is strongly dependent on the carrier-envelope phase (CEP) of the laser pulses (3). Depending on the CEP, we observe that spectral photon orders come and go, and can interpret this effect with matter wave interference in the time-energy domain: for certain setting of the CEP, two slits in time exist, leading to interference, whereas for other settings only a single slit exist, hence no interference fringes (photon orders) are visible but a broad continuum. Because the active electron is very sensitive to the local field strengths, we can show that this system represents a near-field sensor with a record resolution of 1nm (4). If time permits, we will also show results on direct laser acceleration of electrons in the near-field of a grating structure. In this proof-of-concept experiment, we have observed a maximum acceleration gradient of 25 MeV/m, which is already comparable to state-of-the-art radio-frequency accelerators (5).

(1) M. Schenk, M. Krüger, P. Hommelhoff, Phys. Rev. Lett. 105, 257601 (2010)
(2) G. Wachter, Chr. Lemell, J. Burgdörfer, M. Schenk, M. Krüger, P. Hommelhoff, Phys. Rev. B 86, 035402 (2012)
(3) M. Krüger, M. Schenk, P. Hommelhoff, Nature 475, 78 (2011)
(4) S. Thomas, M. Krüger, M. Förster, M. Schenk, P. Hommelhoff, submitted, arXiv:1209.5195
(5) J. Breuer, P. Hommelhoff, to be published

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