Tracing ultrafast light-induced dynamics: from strong-field physics to femtochemistry

Artem Rudenko

Max Planck Advanced Study Group at the Center for Free-Electron Laser Science, Hamburg, Germany

Over the last thirty years rapid development of novel intense short-pulsed coherent radiation sources such as femtosecond optical and infrared lasers, their higher-order harmonics in the extreme ultra-violet (EUV) domain, and EUV/X-ray free-electron lasers, opened up a variety of exciting new possibilities to visualize structure of matter, and to trace its dynamical evolution on a length and time scales of single atom motion. In particular, significant advances had been recently made towards coherent diffractive imaging of nano-scale objects with nearly atomic resolution, tracing photo-induced chemical reactions in real time and defining properties of molecular transition states. The basic idea here is that the availability of ultrashort intense light bursts in a broad range of wavelengths would allow one to initiate different types of dynamics (e.g., create decaying excited state of an atom, prepare bound or continuum molecular wave packet etc), and then to obtain snapshots of the created transient structure faster than the latter evolves (the so-called “pump-probe” scheme). The success of this approach critically depends on our understanding of basic mechanisms of (often non-linear) light-matter interactions, starting from the electronic response of single atoms.

I will present an overview of the experimental program aimed to develop novel schemes of ultrafast time-resolved measurements, and to advance our knowledge on the interaction of atoms, molecules and nano-size particles with intense laser-like radiation of different wavelengths, focusing on the experiments employing (multi-) coincidence momentum imaging techniques for taking snapshots of atomic and molecular structure. Examples will include measurements in optical, EUV and X-ray domains. Current status and future perspectives of different one- and two-color pump-probe schemes, and of various probe methods (including coherent X-ray scattering, Coulomb explosion imaging, photoelectron diffraction and holography) will be discussed.