Tu5

Intense attosecond pulse source for pump-probe experiments

G. D. Tsakiris, R. Hörlein, Y. Nomura, M. Geissler,
K. Eidmann, J. Meyer-ter-Vehn, F. Krausz
Max-Planck-Institut für Quantenoptik,
Hans-Kopfermann-Str. 1, D-85748 Garching, Germany

The advent of attosecond pulse generation has had a tremendous impact on the temporal measurement technology. It has provided the means of temporally resolving dynamic processes evolving at atomic time scales. The technique for the attosecond pulse generation relies on the production of phase-locked harmonics in a non-linear medium using short laser pulses. A number of attosecond spectroscopic measurements have been performed using attosecond sources based on high-harmonic generation in atomic gases. The scope of experiments that can be performed with this source is rather limited though because of the low number of photons available. Since the first observation of harmonic generation from solid targets using a tabletop laser system it became apparent that the interaction of an intense laser pulse with an overdense plasma constitutes an alternative route for the efficient production of phase-locked harmonics. Given the rapid technological advancements in laser technology, tabletop lasers based on the Optical Parametric Chirp Pulse Amplification (OPCPA) technique delivering several tens of TW power with kHz repetition rate appear to be within our reach. Motivated by these prospects, we have performed a series of simulations using the 1-D particle-in-cell (PIC) code LPIC. The results indicate that it is quite feasible that surface harmonics generated at laser intensities of 10^{20} W/cm^2 can produce a train of or even single attosecond pulses in the 20 - 70 eV spectral range with duration of ~80 as and efficiency of a few percent. More elaborate simulations using a 3D-PIC code not only corroborate these findings but also show that the XUV light reflected from the few-cycle-driven relativistic surface possess an excellent spatial coherence. The prospects of developing a source of intense attosecond XUV pulses using this method will be discussed on the basis of simulation and experimental results. The availability of such a source would allow the extension of the pump-probe femtosecond techniques to the extreme ultra-violet (XUV) and soft x-ray (SXR) regime, thus opening the way to real-time observation of a wide range of fast evolving phenomena in atomic, molecular and plasma physics.