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Theoretical and numerical investigation of ion acceleration in the interaction of high intensity attosecond pulses with solid proton-Boron targets

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Several setups have recently been proposed to generate ultra-short laser pulses in the 10-100 as range with high energies (0.1-10 J) and a wavelength in the EUV-X range (1-100 nm), either by broadening the spectrum of near-infrared laser pulses to obtain single-cycle pulses that can be converted to single cycle attosecond pulses by a plasma mirror, or by directly using Doppler-boosted petawatt-class lasers. The corresponding photon energy range is from 10 eV to 1 keV. Such high energy photons are able to propagate even inside solid density targets and will allow to study the propagation of such pulses in matter, and to explore new regimes of laser-matter interaction with strong application potential as the laser energy involved will be limited and the repetition rate will be high. Another unique feature of this regime will be the ultra-high intensities that will be reached thanks to the very short duration of the pulse itself, and to the small focal spots reachable at these wavelengths.

These new unexplored regimes of interaction have the potential to achieve considerable breakthroughs in high efficiency laser particle acceleration, high efficiency and high energy radiation sources, ultra-high amplitude magnetic field generation and ultra-high pressures. Applications in fundamental physics and extreme laboratory astrophysics will therefore arise linked to high field quantum electrodynamics, nuclear physics and general relativity. We have investigated the interaction of high energy attosecond pulses with solid proton–Boron targets and the associated electron acceleration, ion acceleration, and radiation generation supported by Particle-In-Cell simulations. We demonstrate the efficiency of single–cycle attosecond pulses in comparison to multi–cycle attosecond pulses for transverse ion acceleration and magnetic field generation, making this regime of interaction promising for proton–Boron fusion. We also discuss the influence of the laser and target parameters to optimize longitudinal ion acceleration and high energy radiation generation.

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