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Ultra-high-order harmonic generation in cavitated plasmas[1]

CARL SCHROEDER, Lawrence Berkeley National Laboratory

High-harmonic generation (HHG) using short pulse lasers in gases is a compact method for producing ultrafast, coherent light, but has been limited to the soft x-ray and extreme-ultraviolet spectral regions. The energy of the HHG photons can be increased by increasing the laser intensity and/or the ionization potential of the atom (or ion). At high laser intensities, however, HHG is suppressed by ionization and plasma production, limiting the coherence length via plasma-induced phase slippage. Phase-matching to overcome the plasma-induced slippage has been a critical challenge to further development of HHG x-ray sources. In this talk a novel method for producing hard x-rays via HHG from highly-stripped ions using ultra-intense lasers is described. The method relies on electron cavitation and ion channel formation by the ponderomotive force of an ultra-intense laser pulse or the space-charge force of a relativistic (laser-plasma-accelerated) electron beam. An intense, short-pulse laser propagating in the electron-free ion cavity can produce laser harmonics. A counter-propagating laser pulse train is proposed for quasi-phase matching via periodic suppression of the longitudinal electron motion owing to the magnetic component of the nonlinear Lorentz force for relativistic laser intensities. This method enables the reach of HHG to be extended to the sub-Å regime.

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