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High Harmonic Lasing Using Attosecond Electron Pulse Combs in Photon-Induced Near-Field Electron Microscopy

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Attosecond laser pulses in the extreme ultraviolet/soft X-ray (XUV/SXR) spectral regions are presently available for attosecond pump-probe spectroscopy and extreme ultraviolet lithography for chip manufacturing, ultrafast atomic-scale microscopy, and nonlinear X-ray optics. There are two main approaches to produce attosecond light pulses: high-harmonic generation (HHG) in gas-phase or solid-state matter based on the three-step model, and X-ray free-electron lasers (XFELs) based on self-amplified spontaneous emission (SASE) and laser seeding processes of relativistic free electrons traveling through an undulator. Here, we propose a novel route of producing attosecond laser pulses, based on the generation of attosecond electron pulse trains in photon-induced near-field electron microscopy (PINEM), combined with the SASE principle for light amplification. Our scheme relies on high-density nanotip arrays emitting dense electron bunches that are subsequently modulated with a PINEM-type interaction, enabling high-gain for amplification of XUV/SXR high harmonic radiation. Our PINEM-HHG mechanism using attosecond electron pulses can serve as promising ultra-bright extreme ultraviolet/soft X-ray attosecond laser sources.

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