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Giant isolated attosecond pulses from two-color laser plasma interactions

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Coherent attosecond pulse in the extreme ultraviolet (XUV) and X-ray ranges have high temporal-spatial resolution, which can be widely used as microscopies to explore ultrafast atomic and molecular dynamics, characterizing plasmas by time-resolved x-ray diffraction or use as extreme ultraviolet (XUV) or x-ray pump-probe techniques. To achieve the full potential of the temporal resolution, exploring the matters including nonlinear effects and recording the ultrafast evolution in material, isolated attosecond light pulses with high intensity and large photon energy are required. In principle the interaction of a laser with highly relativistic intensity with plasmas has been identified as a potential route to high-energy attosecond sources, but it is hardly to realize the isolation in current laboratories because most of lasers with such high peak power in the world are multicycle pulses with durations exceeding 20 fs.

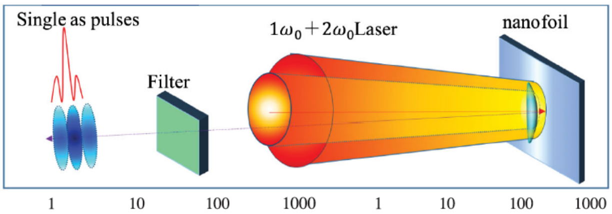

Figure 1: The schematic for obtaining giant, isolated attosecond pulse by a two-color laser-plasma interaction.

Here we highlight a new regime available for the usual multicycle laser system to achieve the emission of extremely intense, isolated attosecond bursts by using the interaction of a two-color (ω, 2ω) laser with a nanometer-scale foil (See Fig. 1). For foils irradiated by lasers exceeding the blow-out field strength (i.e., capable of fully separating electrons from the ion background), the addition of a second harmonic field results in the stabilization of the foil up to the blow-out intensity, which can lead to an essentially single cycle transition in the target state from highly reflective to relativistically transparent. This unique dynamic implies that there is a sharp transition over one cycle with a very large proportion of the foil electrons emitting coherently during the transition cycle, resulting in single, dominant attosecond emission bursts due to coherent synchrotron emission, which is about 40 times stronger than those predicted for a one-color laser (See Fig. 2). Such an intense and isolated attosecond pulse represents a significant advance in the development of attosecond sources for the case of multicycle laser system.

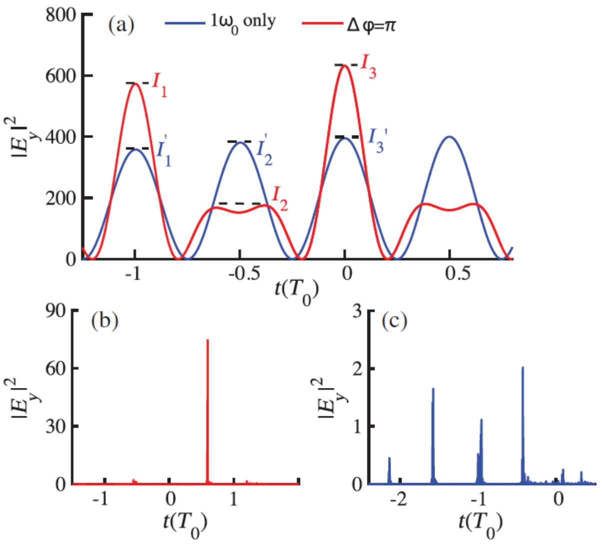

Figure 2: 1D simulation highlighting the difference between two-color with one-color interactions. (a) shows the temporal intensity variation where E_y is in units of $m_e\omega_0c/e$. The reflected XUV emission (filtered from $30-200\omega_0$) in (b) and (c) shows a single attosecond burst for the TC case which is about ×40 brighter than the OC pulse train.

References

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