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Polarization Assisted Amplitude Gating as a Route to Tunable, High-Contrast Single Attosecond Pulses

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Abstract: We demonstrate the simple implementation a polarization-assisted amplitude gate that is capable of generating high-contrast, isolated attosecond pulses tunable between the energy range of 50 – 130 eV.

OCIS codes: (320.7150) Ultrafast spectroscopy; (320.7110) Ultrafast nonlinear optics; (340.7480) X-rays, soft x-rays, extreme ultraviolet (EUV)

Attosecond transient absorption spectroscopy is an excellent technique for probing electron dynamics in an array of complex systems [1]. A few-femtosecond infrared-to-ultraviolet pump pulse is used to initiate a photo-chemical reaction and the dynamics of the reaction are probed with a time-delayed attosecond pulse. The attosecond pulse is tuned to be resonant with core-to-valence transitions in the atom or molecule. These so-called “absorption edges” are element and oxidation-state specific and can therefore disentangle the complex, multi-electron dynamics occurring within chemical processes. However, to probe different elemental absorption edges, energy-tunable isolated attosecond pulses are required.

To achieve tunable, high contrast attosecond pulses, we developed a new technique that combines the properties of both amplitude gating [2] and polarization gating [3]. The technique uses a partial polarization gate to reduce the satellite pulse contamination within the cut-off spectrum during high harmonic generation and extend the bandwidth of the isolated attosecond pulse. We refer to this technique as a Polarization ASSisted Amplitude Gate (PASSAGE). Using PASSAGE, we are able to generate isolated attosecond pulses tunable across the range of 50 – 130 eV, as shown in Fig. 1 (a). The partial polarization gate used in PASSAGE has clear advantages compared to conventional polarization gating since it allows high harmonic generation to be driven with higher peak intensities

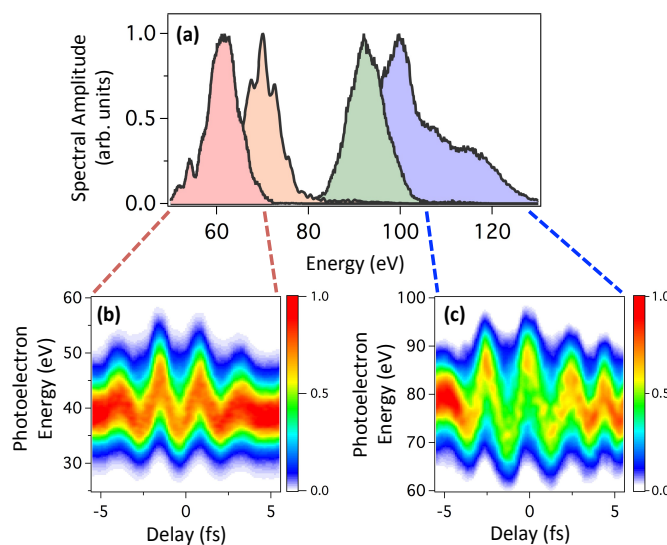


Figure 1 (a) Isolated attosecond spectra generated using PASSAGE and tunable between the range of 50 - 130 eV. (b) Attosecond streaking trace of a pulse centered at 60 eV. (c) Attosecond streaking trace of a pulse centered at 100 eV.

yielding a greater photon flux and central energy. In addition, PASSAGE acts to improve the satellite contrast compared to amplitude gating, thus relaxing the strict pulse duration requirement given by the amplitude gate. We have found that PASSAGE works with driving pulse durations of up to 7 fs.

To confirm the isolation of attosecond pulses generated with PASSAGE, we perform attosecond streaking spectroscopy. Fig. 1 (b) and (c) demonstrate typical streaking traces for pulses generated via PASSAGE in Ar and Ne gas respectively. The traces show no obvious satellite pulse contamination and are reconstructed to obtain pulse durations of 190 as and 140 as, respectively.

Using tunable attosecond pulses generated via PASSAGE, we probe the M-edge of Br and observe coherent electronic wavepackets in small molecules. Future work will look into extending the method of PASSAGE to generate soft x-ray attosecond pulses with He as a driving gas. Preliminary data already suggests that we can create a broadband continuum supporting a 60 as pulse centered near the sulfur L-edge at 165 eV.

References

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