# Isolated attosecond pulses with controlled polarization


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**Abstract**

High-order harmonic generation (HHG) is considered one of the most reliable sources for the generation of coherent EUV/X-ray linearly polarized attosecond pulses. We perform advanced theoretical analysis to show for the first time the generation of attosecond pulses with controlled polarization, by combining two counter-rotating driving beams. In particular we demonstrate that isolated attosecond pulses with circular polarization can be emitted when driving HHG with two non-collinear counter-rotating near-IR beams.


High-order harmonic generation (HHG) is considered one of the most reliable sources of coherent radiation extending from the EUV to the soft X-ray regime [1], in the form of attosecond bursts. It is simply understood in semiclassical terms: an electron is tunnel ionized from an atom by an intense linearly polarized laser field, then accelerated, and finally driven back to its parent ion, releasing the kinetic energy acquired form the field in the form of EUV/X-ray radiation upon recollision. If driven by a circularly polarized field, the electronic wavepacket does not recollide with the parent ion, and it was believed impossible to generate bright circularly polarized EUV light by HHG. This precluded many applications such as X-ray magnetic circular dichroism.

Recently, HHG driven by two-color, collinear, counter-rotating circularly polarized pulses was experimentally demonstrated to produce bright circularly polarized EUV light, as proposed theoretically in the early 2000s [2,3]. This enabled the first tabletop implementation of X-ray magnetic circular dichroism (XMCD) measurements. However, this collinear, two-color (ω+2ω) HHG scheme limits the maximum HHG photon energies produced compared to HHG driven with only the fundamental frequency ω.

We present a novel scheme to produce circularly polarized harmonics through noncollinear mixing of counter-rotating, circularly polarized driving lasers of the same color (NCP-HHG) [4]. This technique maximizes the cutoff photon energies and simultaneously produces separate beams of R and L polarization for each harmonic, enabling precision differential measurements of circular dichroism.

In this contribution we perform advanced theory to characterize the attosecond pulses emitted from both schemes. We show that collinear, two-color driven HHG produces a pulse train of attosecond pulses consisting of three linearly polarized attosecond bursts per laser cycle, where the polarization rotates 120 degrees between each burst. By changing the intensity ratio between the two colors, linear to elliptical attosecond pulses can be obtained. On the other hand, NCP-HHG generates truly circular attosecond pulses, and to our knowledge it is the first scheme that allows for the generation of isolated circularly polarized attosecond pulses.

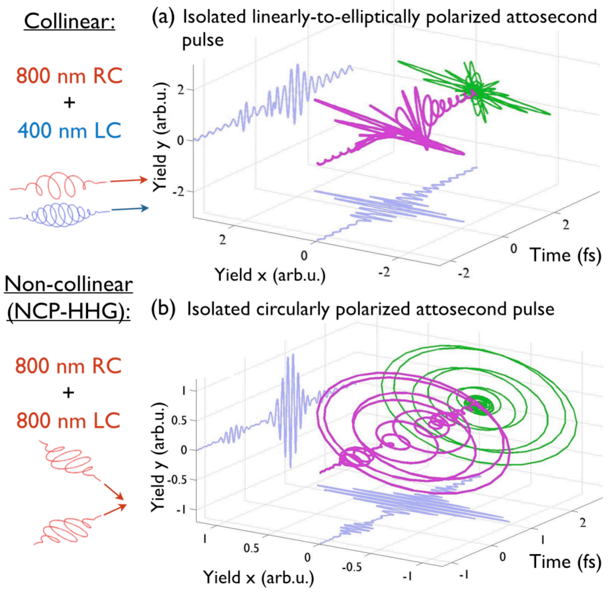


**Fig. 1**. (a) Linearly polarized isolated attosecond pulse emission when driving HHG by collinear, two-color (800 nm R circular + 400 nm L circular), few-cycle laser pulses, compared to truly circularly polarized emission obtained when driving HHG by non-collinear, one-color (800 nm R circular + 800 nm L circular), few-cycle laser pulses. Light blue lines show the projections into x and y components, and green lines shows integration over time.

## References


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