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Magnetically-pumped High Harmonic Generation with circularly polarized driving fields

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High Harmonic Generation (HHG) is well-stablished as a standard tool to obtain coherent high-frequency light emission and attosecond pulses [1]. In the most common scheme, a linear-polarized electric field interacts with an atomic gas jet generating a fast-oscillating dipole. The process results in the emission of high-order harmonics whose spectrum is characterized by a broad plateau that extends towards a cut-off frequency. On the other side, the simultaneous development of ultrafast structured light beams is opening new scenarios to control strong light-matter interactions. In particular, it has been recently proposed that isolated Tesla-scale femtosecond magnetic fields can arise from azimuthally polarized vector beams [2], enabling alternative perspectives in ultrafast magnetism, spintronics [3], and, why not, in ultrafast, nonlinear, and quantum optics.

In this work, we pioneer a new mechanism in HHG through the use of a circularly polarized electric field simultaneously pumped by a strong, isolated linearly polarized magnetic field. We numerically solve the three-dimensional time-dependent Schrödinger equation in the hydrogen atom. While in the standard HHG scheme the efficient generation of high order harmonics is not feasible with circularly polarized drivers [4], we show that the combined use of intense linearly polarized PHz oscillating magnetic fields not only allows the generation of high-order harmonics, but extends the cut-off frequency by hundreds of harmonic orders (Fig. 1 a). Remarkably, the attosecond pulse associated with the extended spectrum exhibits elliptical polarization with a temporal width of ~80 attoseconds (Fig. 1 b). In this proposal, linearly polarized isolated magnetic fields over 10^4 T are considered, which can be obtained from the use of a stationary wave generated by two counter-propagating laser beams (Fig. 1 c) with intensities around 10^{18} W/cm^2. Such laser beams are easily achieved nowadays in petawatt laser facilities. The stationary wave generates a slab grating in the gas target where the HHG process takes place, therefore diffracting at different angles the generated harmonics. Our work introduces novel HHG schemes aided by petawatt lasers, allowing exotic configurations and the generation of extremely broad high harmonic spectra towards the X-rays.

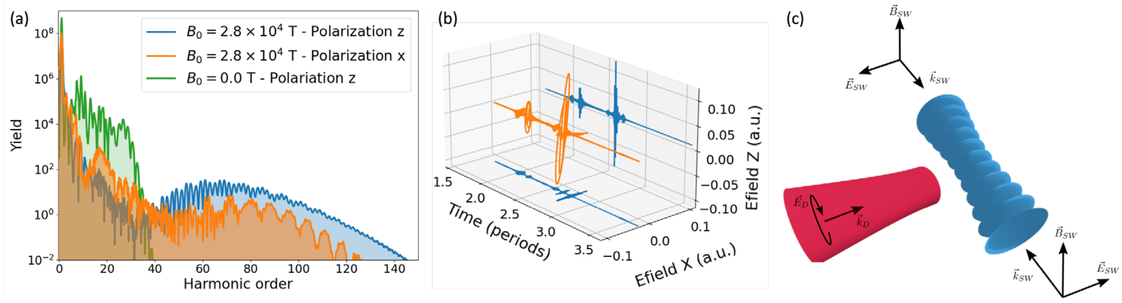

Figure1. (a) HHG spectrum for the standard scheme (linearly polarized driving beam along the z direction) in green, compared with the generated spectrum using the circularly polarized driving beam (in the x-z plane, four-period 800 nm pulse with a peak intensity of 1.610^{14} W/cm^2) simultaneously pumped with a 800 nm linearly polarized magnetic field of 2.810^4 T (blue and orange stand for the z and x components. (b) Attosecond pulse obtained after filtering the HHG spectrum in (a) above the 60th harmonic order. (c) Scheme of the stationary wave configuration, where the circularly polarized Gaussian driving beam ($\vec{E}_D$) simultaneously pumps HHG with the slabs of magnetic field (blue) arising from the vertically polarized stationary wave ($\vec{B}_{SW}$).

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