Photoelectron spin polarization in bichromatic-field ionization of atoms

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Synopsis Photoelectron spin polarization may be effectively controlled in ionization induced by the combined action of the fundamental and the second laser harmonics by variation of their relative intensity, phase and polarization. Appropriate choice of the pulse parameters allows moving the maximum of spin polarization towards the maxima in the differential cross section and making it thereby easier to observe.

Spin polarization of photoelectrons has attracted attention for decades as a fundamental phenomenon and as an attribute in applications. Spin polarization shows up due to differences in the wavefunctions of the fine-structure components, which are revealed in this or that way (separating fine-structure levels of the target atom or the photoion, spin-orbit interaction in atomic continuum). The main reasons for the scarce studies of the photoelectron spin polarization in experiments with isolated atoms are related to the crucial decrease of efficiency of spin-sensitive detectors and the fact that essential spin polarization is often reached at photon energies in the minima of the cross sections.

Ionization of an atom by the combined actions of the fields of the fundamental (ω) and the second (2ω) laser harmonics $\mathbf{E}(t) = \boldsymbol{\varepsilon} E_0(t)$ $(\cos \omega t + \eta \cos (2\omega t + \phi))$ provides the opportunity to control the angular distribution and the spin polarization of photoelectrons by manipulating the relative phase ϕ and strength η of the second harmonic. This possibility was recently discussed for alkali atoms in the optical range [1] and the first results are available for photoprocesses in condensed matter [2]. The advent of free-electron lasers producing intense coherent XUV light with variable polarization may open new avenues in studies and control of the photoelectron spin polarization. Current research aimed extending these investigations to the high-frequency domain and to strongly correlated targets, such as noble gases.

Interference between resonant two-photon ionization by the fundamental and direct one-photon ionization by the second harmonic provides a mechanism to control both photoelectron angular distribution [3] and spin polarization. Results of this interference may appear in a crucial way. For instance, if both harmonics are linearly polarized, neither single nor two-photon ionization of an atom produce electrons polarized in the plane spanned by the polarization vector and the emission direction, but the interference does. An example of such a polarization is presented in figure 1. The original cause of the photoelectron spin polarization in our case is spin-orbit interaction in the intermediate excited state leading to fine-structure splitting and term mixing. The spin polarization vanishes after summation over the fine-structure levels.

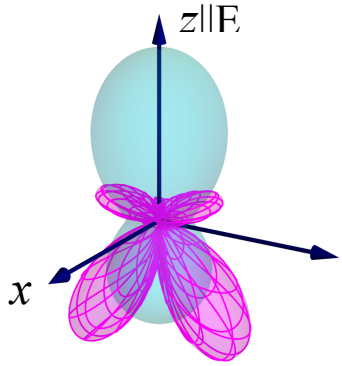

Figure 1. PAD (blue) and absolute value of spin polarization along the x-axis (magenta, dashed) at ω corresponding to the excitation of the lowest $2p^5[^2P_{3/2}]3s_1$ state in neon. The pulse parameters: intensity 10^{12}W/cm^2, $\eta = 0.03$, $\phi = 0$, duration 250 optical cycles; the harmonics are linearly polarized. The maximum of spin polarization is about 20%.

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References

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