Photoelectron angular distribution in two-color atomic ionization

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Synopsis Theoretical aspects of photoelectron angular distributions are discussed with reference to two-color ionization with either two XFEL beams or XFEL and optical laser beams. Specifically, we consider non-dipole effects in different kinds of dichroism in above-threshold ionization and an asymmetry in the angular distributions due to interference between the ionization paths from the fundamental and second harmonic.

The recent commissioning of XFELs, producing very high-brilliant femtosecond radiation pulses in the XUV regime, has opened new avenues in studies of such a developed field as the photoelectron angular distribution (PAD) in atomic ionization. Keeping in mind applications to photoprocesses with XFELs we concentrate on the theoretical description of two phenomena: (a) nondipole effects in the PADs of two-color above-threshold ionization (fig. 1a), and (b) interference effects in two-pathway ionization by the fundamental near an intermediate atomic resonance (two-photon ionization) and its second harmonic (one-photon ionization) (fig. 1b). In both cases quantum interference, which mixes parity-changing and parity-conserving transitions, plays a crucial role. This mixing breaks one of the symmetry planes in the PADs.

For process (a), we predict modifications of the PAD and a dichroism originating from the interference between the electric dipole (E1) and quadrupole (E2) amplitudes. Different polarizations of the XFEL and optical laser beams are considered, new terms in the PADs are predicted, and the results are exemplified by numerical calculations for the ATI from the s-subshells of Ne and Kr within second-order perturbation theory.

For process (b) we propose using an admixture of the second harmonic, which is routinely generated at XFELs. The PAD and its asymmetry sharply change as function of the photon energy. As specific examples, ionization from the ground states of hydrogen and helium atoms is analyzed in the vicinity of the 1s-2p transitions. Here we solve either the time-dependent Schrödinger equation or again apply perturbation theory. Within perturbation theory, parameterizations are derived for the anisotropy parameters in the PAD and the asymmetry in the region of an isolated intermediate resonance. General features of these observable quantities are revealed as functions of the photon energy, the relative contribution of the second harmonic, and the relative phase between the fundamental and its second harmonic. Particular prescriptions are formulated regarding the extraction of the essential dynamical information on the photoionization process via PADs in tight control of the XFEL beam parameters. A possibility for measuring the relative phase of the fundamental and the second harmonic is considered.

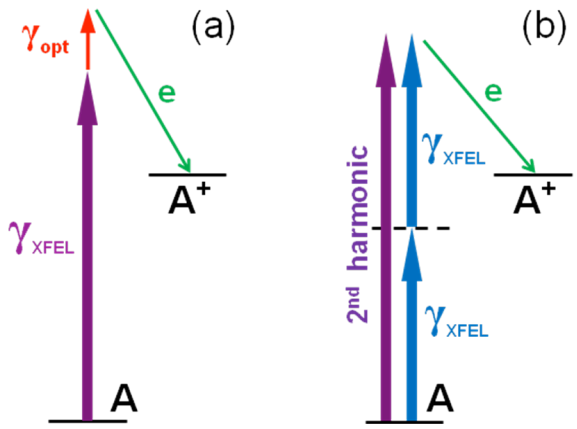

Figure 1. Schemes of two-color photoionization.

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References

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