Strong-field ionization beyond the dipole approximation: elliptictiy dependence, rescattering and holographic interferences

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Synopsis We present an overview of our work on strong-field ionization beyond the electric dipole approximation with the focus on rescattering and parent-ion interaction in mid-IR laser fields with low ellipticity. The interplay of the laser magnetic field component and the parent-ion interaction of outgoing photoelectron leads to modifications of the photoelectron momentum distributions along the beam propagation direction. These modifications include Coulomb focusing, rescattering as well as the modulation of the phase of the electron that is visible in holography-type interferences.

In strong-field ionization with mid-IR laser fields, the influence of the interaction beyond the dipole approximation has a significant influence on the final momentum of the photoelectron. Due to high kinetic energies that are achieved in mid-IR laser fields already at moderate intensities on the order of 10^{13}W/cm^2, the magnetic component of the Lorentz force plays a significant role. Moreover, for linear polarization and small elliptcities, the influence of the laser magnetic field is modified by the interplay with the parent-ion interaction upon recollision [1].

We recorded full 3D photoelectron momentum distributions (PMD) from strong-field ionization of xenon atoms with 50 fs long mid-IR pulses at a center wavelength of 3.4 µm and a peak intensity of ~$5 \cdot 10^{13}$ W/cm^2 at linear polarization and small ellipticities.

Coulomb focusing upon recollision leads to the creation of a sharp ridge in the final PMD. Within a certain range of the laser ellipticity, the electrons in this ridge are clearly separated from the two lobes that commonly appear in the PMD with elliptically polarized laser fields (Fig. 1 (a)). These ridge electrons are directly related to a counterintuitive shift of the PMD peak opposite to the laser beam propagation direction when the dipole approximation breaks down [2]. By increasing the ellipticity, the ridge structure disappears and the PMD peak is shifted towards beam propagation direction. From our analysis, we obtained a relationship between the initial momentum of the ridge electrons, the drift momentum of the electron due to ellipticity and due to non-dipole effects as well as the momentum transfer upon recollision [3]. We could identify the range of ellipticity for which the ridge appears.

Furthermore, we present the first experimental observation of the influence of the magnetic field onto holography interference patterns from strong-field ionization. The measurements reveal a p_x-dependent asymmetry in the holographic interference pattern (Fig 1(b)).

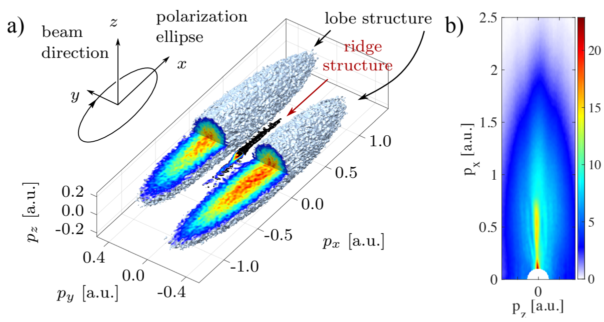

Figure 1. (a) Isosurface of a 3D PMD with a partial cut in the polarization plane recorded at an ellipticity of $\epsilon = 0.11$. The ridge structure (which is due to rescattering of ionized electrons with the parent ion) around $p_y = 0$ is clearly separated from the common main lobes. (b) Cut through a PMD recorded with linear polarization in the plane spanned be the polarization axis (p_x) and the beam propagatin direction (p_z). The asymmetry of the holographic interference structures is most obvious for $|p_x| < 0.7$.

References

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