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Control of strong-field ionization with two-color laser pulses

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Synopsis Experimental results and theoretical analysis of the ionization process of argon atoms interacting with linearly polarized two-color fields ($\lambda_1 = 800\,nm$, $\lambda_2 = 400\,nm$) are presented. We observe complex asymmetry patterns in the measured three-dimensional momentum distributions.

Strong-field ionization of atoms with near infra-red laser pulses reveals a rich structure in the momentum distribution of the liberated electron. The patterns observed (Fig. 1) arise from the interferences of multiple pathways leading to the same final momentum state. They retain precise information about the creation of electron wave-packets in the laser field and the phase they accumulate during the propagation in the combined laser and ionic Coulomb field [1].

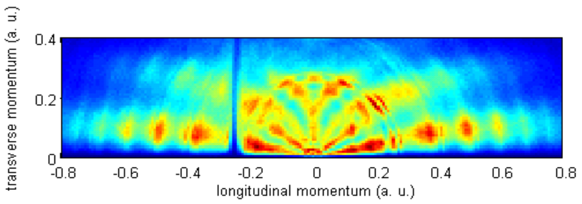

Figure 1. Electron momentum distribution for ionization of Ar by 800 nm, 25 fs pulses (intensity 2×10^{14} W/cm^2).

We study the ionization of argon with shaped two-color laser fields. They are formed by the combination of 800 nm femtoseconds laser pulses and their frequency-doubled component (400 nm).

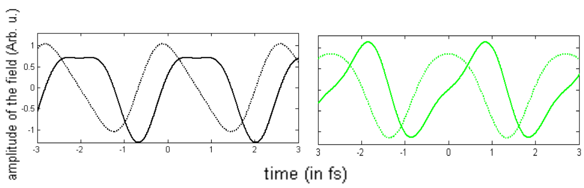

Figure 2. Shapes of the laser electric field (solid line) and its vector potential (dotted line) for different phases between red and blue carriers: $0.25\,\pi$ (left) and $0.5\,\pi$ (right).

By controlling the relative phase between the red and blue carrier waves (Fig. 2), we can control the ionization rate via the temporally modified electric field strength. More importantly this shaped field controls also the trajectories of the ionized electron and the accumulated phase leading to modified interference structures in the 3-dimensional momentum distributions. We precisely monitor the modifications of the interference structures (Fig. 3).

Electron momentum distributions are recorded with a reaction microscope and compared to simulated spectra.

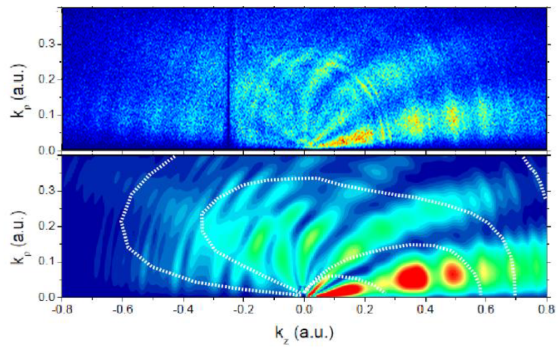

Figure 3. Measured (upper panel) and TDSE (lower panel) momentum distributions of photoelectrons for relative phase $\varphi = 0$. The contour lines on the lower panel mark isolines of the CTMC simulation.

We also perform a study of classical-quantum correspondence in the simulation of laser-atom interactions. We find a surprisingly good agreement between CTMC and TDSE simulations which might open the pathway for an improved understanding of previously unexplained features observed in experimental spectra.

References

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