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Control of atomic single and double ionization dynamics using orthogonally polarized two-color laser pulses

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Synopsis Single- and double-ionization of neon with orthogonally polarized two-color (OTC) laser fields is investigated using the COLTRIMS method. We study the influence of the long range Coulomb potential of the parent ion on the final momentum distribution of electrons emitted during single ionization. Furthermore, we investigate nonsequential double ionization in OTC fields and demonstrate that the electron-electron correlation is highly sensitive to the sub-cycle field shape of the OTC pulses, in agreement with recent theoretical predictions.

Angstrom and attosecond control of free electron wave packets is one of the pinnacles of attosecond science. Orthogonally polarized two-color (OTC) laser fields allow to control the motion of field-ionizing electronic wave packets both in time and space [1]. In OTC pulses time and space are connected and thus an attosecond time scale is established in the polarization plane for both the emitted and the recolliding wave packets [2,3].

In this submission, we report on experiments that use OTC pulses for studying atomic single and double ionization. The three-dimensional momentum vector of electrons and ions created by single and double ionization of neon atoms was measured with the COLTRIMS technique as a function of the sub-cycle shape of the OTC pulses.

Fig. 1(a) shows the measured momentum distributions of electrons correlated with singly ionized neon in the polarization plane of the OTC field with relative phase Δφ between the two color components. The spectra show that the electron emission is sensitive to Δφ. Furthermore, the spectra feature a prominent x-shaped central structure and weaker fine-scale modulations due to wave packet interferences. By comparison with simulated spectra using the strong field approximation (SFA) and by solving the two-dimensional time-dependent Schrödinger equation (TDSE) within the single active electron approximation, we conclude that the ion's Coulomb field strongly affects the spatial distribution of released electron wave packets.

We furthermore demonstrate control over the correlation between the two electrons emitted during double ionization upon electron recollsion by tuning the shape of the electric field of the OTC pulses on the sub-cycle scale. Analysis of the spectra of the sum momentum vector in terms of their mean values and widths along the polarization directions of the two colors allows obtaining detailed insight into the correlated electron emission dynamics. Our analysis reveals that for certain relative phases Δφ a very strong electron-electron anti-correlation is obtained in exact agreement with theoretical prediction [4]. Thus, our measurements demonstrate that by using OTC laser fields it is possible to control the electron-electron correlation during NSDI by using Δφ as the control parameter.

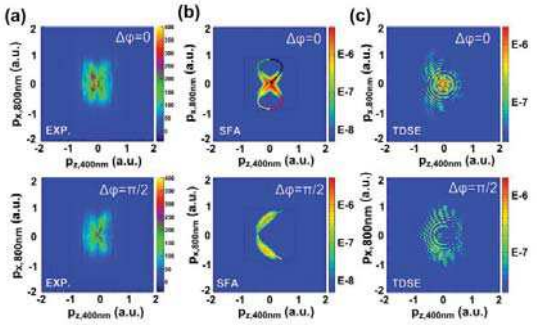

Figure 1. (a) Measured electron momentum distributions from single ionization of neon atoms in the laser polarization plane. (b) Calculated electron momentum distributions using the SFA. (c) Simulated electron momentum distributions obtained by solving the two-dimensional TDSE within the single active electron approximation.

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