Symmetries, Dominance and Quantum Interference in Below-Threshold Non-Sequential Double Ionization with Tailored Fields

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The ability to control laser-induced processes like non-sequential double ionization (NSDI) using tailored fields is a powerful tool for understanding electron dynamics at ultrafast timescales. Symmetry provides a systematic way to understand the imprint of the field and the target on the resulting photoelectron momentum distributions (PMDs) [1]. Additionally, quantum interference remains pivotal in strong-field physics, persisting despite focal averaging and integration over degrees of freedom perpendicular to the field [2].

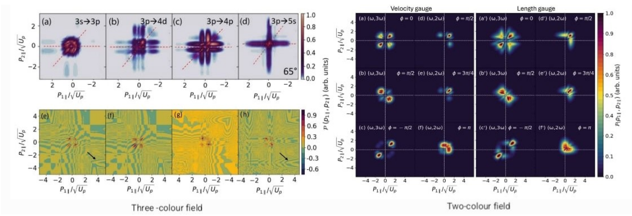

Figure 1: Fully coherent correlated two-electron momentum distributions as functions of the momentum components $p_{1\|}p_{2\|}$ parallel to the driving-field polarization, calculated for several excitation channels using a $\sin^2$ pulse of 4.3 cycles, intensity $I = 1.5 \times 10^{14}\mathrm{W/cm}^2$, angular frequency $\omega = 0.057$ a.u. and CEP $\varphi = 65°$ [left panels (a)-(d)], and using bichromatic fields with prefactors in the velocity and length, calculated for the $(\omega, 3\omega)$ and $(\omega, 2\omega)$ driving fields with the relative phase as indicated in the panels. The ratio of the field amplitudes is $\xi = 0.8$. The difference between the fully incoherent and coherent RESI distributions is shown in the lower left row for the same parameters as the top left row

We investigate the recollision-excitation with subsequent ionization (RESI) mechanism with linearly-polarized two- and three-color driving fields [3,4]. Using the strong-field approximation (SFA), we assess how field symmetries influence the dominant events. By manipulating field parameters like frequencies and relative phases between the driving waves and the carrier envelope phase, we show how one can influence the correlated electron-momentum distribution, and identify which symmetries are broken or retained. A systematic analysis of quantum interference is performed by generalizing and elaborating several analytic interference conditions for RESI with arbitrary driving fields, with a focus on interference arising from the specific symmetries of fields studied. A rich tapestry of superimposed interchannel interference fringes originating from phase differences related to symmetrization, temporal shifts and a combination of temporal-exchange interference is revealed, including ‘spines’, hyperbolae, chequerboards and even ‘feathers’. Figure 1 provides some examples for two and three colour fields. The field plays a critical role in illuminating certain interference patterns [5]. This also holds for intrachannel interferences [6]. Furthermore, to incorporate Coulomb effects, we employ a hybrid model combining rescattered SFA and direct Coulomb-Quantum SFA (CQSFA). The role of the Coulomb interactions in altering the symmetries of the PMDs, and resulting interference was explored with monochromatic fields [7]. These results all provide an insight into how PMDs and interference patterns can be controlled or confined in specific momentum regions.

References

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