

A Systematic Study of Interference Effects in Non-Sequential Double Ionisation

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Synopsis We perform a detailed study of interference in time-delayed NSDI showing significant effects on the momentum dependent transition amplitude. We also provide analytical arguments to back up our findings.

The importance of quantum interference in strong-field Non-Sequential Double Ionisation (NSDI) has become an open question. Up to the past year, it was widely believed that it did not play a significant role. This may be attributed to the success of classical NSDI models [1, 2] and to studies assessing the classical-quantum correspondence in the context of the electron impact ionization mechanism, in which the first electron, by re-colliding with the core, immediately releases a second electron [4]. In particular it has been shown that interference effects present in the momentum dependent probability distribution will not survive integration over momentum components perpendicular to the laser field.

Recently however it has been argued, in the context of the re-collision with subsequent ionization (RESI) mechanism, that quantum interference is of major importance [3]. It has been found that the interference between the transition amplitudes associated with different excitation channels may lead to breaking of a fourfold symmetry in the momentum distribution, resulting in distributions to be concentrated in the second and fourth quadrants of the plane spanned by parallel momentum components, agreeing with experimental findings [5].

Using the strong field approximation (SFA), we present an analysis of the types of interference that can take place in NSDI, which may occur (a) between events which are displaced by a half cycle and those present due to the symmetry of indistinguishable electrons, (b) between different channels of excitation for the second electron and (c) between different electron orbits.

Our results show significant effects in the electron momentum distribution. The most notable effect arising from the interference of events shown in figure 1. This coherent superposition of events gives rise to diagonal and hyperbolic fea-

tures in the probability distribution that can be partially recovered by a fully analytical analysis of the symmetry transformed actions. The results also show symmetry breaking of the momentum probability distribution with the original distribution being distorted towards the 1st and 3rd quadrants, which is more consistent with experimental results [5]. Further work investigates the effect of the spatial geometry of the bound states to which excitation occurs, which is contained in momentum-dependent prefactors.

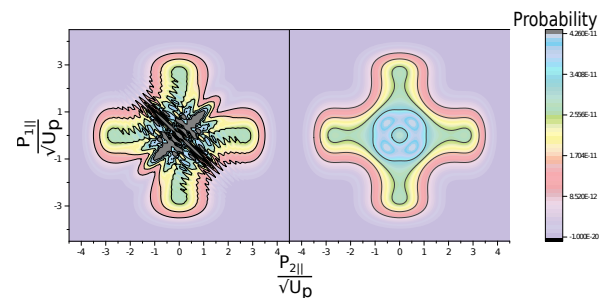


Figure 1. Shows the probability distribution for Argon from a coherent sum of symmetrised events (left) vs an incoherent sum of events (right). The orbital-dependent pre-factors have been neglected. These results show clear evidence of quantum interference in RESI, which demonstrates that classical models leave out important effects.

References

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