Polarisation Effects in Above-Threshold Ionisation of Excited Helium

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Synopsis We present work on the disentanglement of core dynamics and binding potential influences for Above-Threshold Ionisation in Helium prepared in an excited p state, interacting with a mid-IR field. This was formed by comparing the Coulomb Quantum-Orbit Strong-Field Approximation (CQSFA) with B-spline Algebraic Diagrammatic Construction (ADC) simulations. This may lead to the identification of initial momentum distributions, for tunneling and re-scattering instances, from the CQSFA perspective. The latter method is an inverse approach; thus, the ADC simulations will allow comparison of findings.

Re-scattering effects in Above-Threshold Ionisation (ATI) are known for over twenty-five years and in general can be reasonably reproduced by using standard quantum orbit trajectory methods, such as the Strong-Field Approximation (SFA). For recent reviews see "The Plateau in Above-Threshold Ionisation: the Keystone of Re-scattering Physics" [1] and "Symphony on Strong Field Approximation" [2].

Thereby, a key issue in re-scattering is the shape of the electronic bound state from which the electron leaves or to which it returns. However, for certain orbital geometries, standard quantum trajectory methods such as the SFA erroneously lead to vanishing signals from re-scattered trajectories in the photoelectron spectra. This is because the SFA only considers re-scattering orbits that exactly pass through the origin and neglects any deflection caused by the residual Coulomb potential [3].

A striking example of this, is Helium prepared in an excited p state, whose orientation is orthogonal to that of a linearly polarised laser field [4]. Ab-initio methods, reveal that, in contrast to the SFA predictions, the ATI signal from this type of configuration is non-vanishing.

In this work, we have disentangled the different physical mechanisms that contribute to this effect; namely, the core dynamics and the interplay between the field and the residual binding potential for Helium. This is undertaken by comparing the Coulomb Quantum-Orbit Strong-Field Approximation (CQSFA) with ab-initio methods, namely B-spline Algebraic Diagrammatic Construction (ADC), that allow for core excitation and polarisation effects [5].

We also identify the main types of orbits responsible for a non-vanishing ATI signal within the CQSFA and possible initial momentum distributions of the instances of tunnelling and re-scattering by using the ADC model as a benchmark as the CQSFA is an inverse approach.

References

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