Harmonic Generation in Time-dependent R-matrix theory

Andrew C. Brown, Hugo W. van der Hart

Centre for Theoretical Atomic, Molecular and Optical Physics
Queen's University, Belfast. BT7 1NN
abrown41@qub.ac.uk

The striking developments in attosecond physics have breached previously impenetrable limits in our understanding of fundamental physical structure and dynamics [1,2]. Specifically, the process of harmonic generation (HG) has allowed us to measure and control electron dynamics on the sub-femtosecond time-scale. The ultrafast dynamics of electrons in intense laser fields thus represents a forefront for our understanding of fundamental physics. However, despite the leaps in experimental attosecond physics, the theory of the underlying mechanisms is underdeveloped.

In describing such processes, it is important to address the complexities of the atomic structure, and specifically the role of multi-electron interferences. To this end we have developed time-dependent R-matrix (TDRM) theory- an *ab initio*, non-perturbative computational model for the description of general multi-electron atoms in short, intense laser pulses [3]. TDRM has been used previously to connect the correlated motion of two electrons to rapid oscillations in the total ionization yield from C^+ [4], and has now been extended to allow the description of harmonic generation from multi-electron atoms [5-7].

There has been a great deal of discussion in the literature as to the best method of calculating the harmonic yield from a single atom- there are analogous methods utilising the dipole length, velocity and acceleration operators [8,9]. We use newly developed capability in TDRM to demonstrate the advantages and disadvantages of these methods in addressing a helium atom in a 390-nm laser field. We also explore different methods of modelling the atomic structure, and build up a clear picture of the various parameters which affect the calculation of harmonic yield in atomic systems via a comparison with results from the HELIUM code [7,10].

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