Relativistic dynamics for hydrogenlike systems exposed to intense electromagnetic fields

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The fast development in laser technology has lead to steadily increasing laser intensities. With these being high enough, particles are driven to relativistic velocities and the electron dynamics should be treated within the framework of the Dirac equation. Also the trend towards shorter and shorter wavelengths call for a relativistic treatment of the light-matter interaction: when probing core electrons in high-Z elements we are inevitably in an environment where relativistic effects play an important role.

Compared to the time-dependent Schrödinger equation, the time-dependent Dirac equation presents several new challenges. First the number of needed basis functions, at a given level of approximation, doubles due to spin-orbit coupling. Then the presence of the negative energy solutions doubles the space once more. Finally, intense enough fields force us to eventually leave the dipole-approximation leading to additional time and space requirements on the numerical procedure.

In a previous study [1] we solved the time-dependent Dirac equation using a finite basis set obtained by diagonalization of the Dirac equation on a mesh. Among the interesting findings in this study was the importance of virtual electron-positron pairs for the effects beyond the dipole approximation. Unfortunately this also means that negative energy states cannot just be neglected, and in addition it is putting severe constraints on the time-propagation schemes. In fact, we could at that time not fully explore the effects beyond the dipole approximation due to the complexity of the problem.

Here we will present work in progress to minimize the space and time requirements. A B-spline basis is used and new ideas for the time-propagation is explored.

References:

[1] S.Selstø, E.Lindroth, J.Bengtsson, Phys. Rev. A **79**, 043418 (2009).