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Interaction of atomic hydrogen with a UV pulse: model based calculations of the energy transfers from the laser field into both the electron kinetic energy and the harmonics.

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Synopsis We study both the above-threshold ionization spectrum and harmonics generation resulting from the interaction of atomic hydrogen with a UV pulse. Our calculations are based on the solution of the time-dependent Schrödinger equation in momentum space where the kernel of the non-local Coulomb potential is replaced by a sum of separable potentials, each of them supporting one bound state of atomic hydrogen. It is shown that the interaction of hydrogen with a field, the frequency of which corresponds to the 1s-2p transition, leads, quite unexpectedly, to the emission of very energetic electrons.

The existence of "plateau" structures in cross sections has been investigated for over two decades in many nonlinear atom-field interaction processes, as e.g., above-threshold ionization (ATI) and high order harmonic generation in the infrared frequency regime. Indeed, such "plateau" leads to the possible transfer of large amount of energy from the field into either the electron kinetic energy or the high order harmonics without significant decreases in the yields.

In this contribution, we consider the interaction of UV lasers with atomic hydrogen. By starting from the time-dependent Schrödinger equation (TDSE) in momentum space, we develop a model in which the kernel of the non-local Coulomb potential is replaced by a finite sum of separable potentials. Each separable potential supports one bound state of atomic hydrogen [1]. Here, we consider only the 1s, 2s and 2p states. In this way, the full 3-dimensional Schrödinger equation reduces to a system of a few coupled 1-dimensional linear Volterra integral equations.

This approach has significant advantages. It provides a rigorous solution for the electron wave packet, includes as many bound states as we want, takes into account the continuum-continuum transitions, and is gauge invariant.

In order to validate the model, we have checked that in the perturbative regime, when the ponderomotive potential is smaller than the laser frequency, the corresponding behavior of the ionization yield as well as the ATI spectrum are well reproduced. Furthermore, we have shown that the resonant coupling of the 1s to the 2p states leads to Rabi oscillations of the corresponding populations at the correct frequency as well as to a Rabi splitting of the ATI peaks as shown in Fig. 1. Surprisingly enough, the ATI spectrum shown in this Figure, exhibits a very long plateau, leading to the emission of extremely energetic electrons. This effect will be discussed in detail and the results will be compared to those obtained by solving the TDSE numerically for atomic hydrogen either on a huge grid or by means of a large size spectral basis.

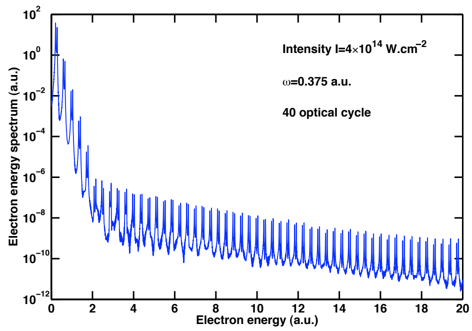

Figure 1. Electron energy spectrum resulting from the interaction of our model atom, initially in the $1s$ state. The pulse has a trapezoidal shape with a 2 optical cycle linear turn on and off and a 36 optical cycle flat top.

References

[1] H.M. Tetchou Nganso, Yu.V. Popov, B. Piraux, J. Madronero, M.G. Kwato Njock 2011 *Phys. Rev.* A **83** 013401.

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