Photoionization of atoms and molecules by IR and XUV laser pulses

R Della Picca

CONICET and Centro Atómico Bariloche, CNEA, Bariloche, 8400, Argentina

Comprehensive understanding of nonlinear nonperturbative laser-atom interactions is essential for attosecond science progress. Accurate information of this interaction is present in the Photo-Electron (PE) spectrum where, the electronic structure of the target and the laser characteristics are encoded. A fundamental questions are how to decode this information from the PE spectrum and what structures come from the target and which ones come from the laser.

In some cases it is possible to write the ionization probability factorized into two contributions: one that accounts for the effect of the laser field on the free electron and a second factor that depends only on the target structure [1]. However, in most cases of interest both contributions can not be analyzed independently, since the target and laser informations are coupled in a non-trivial way. In view of this, we can distinguish three scenarios depending on the origin of most relevant PE spectrum structures: i) coming from the target electronic structure, ii) from the laser pulse temporal profile and iii) when target-laser coupling dominates the emission process.

At the conference, we will present a theoretical example for each scenario. First, we consider the photoionization of H_2^+ by long XUV pulses, where the principal structures are the Cooper-like minima coming from Young-type interferences due to the coherent electronic emission from each nucleus [2]. Secondly, we present the Above Threshold Ionization (ATI) PE spectrum of H($1s$) by a few-cycle intense IR laser pulse (see Figure). Due to the non-constant envelope, the ponderomotive energy U_P (as the cycle averaged quiver kinetic energy) also depends on each cycle. Then, substructures around the ATI peaks are expected at the position given by the energy conservation rule: $E_n = n\omega - I_P - U_P$ depending on the ionization time [3]. Finally, in Laser Assisted Photo-Emission (LAPE) process from Argon, the electronic spatial distribution is entangled with the temporal laser symmetry given rise to a selection of the sideband orders.

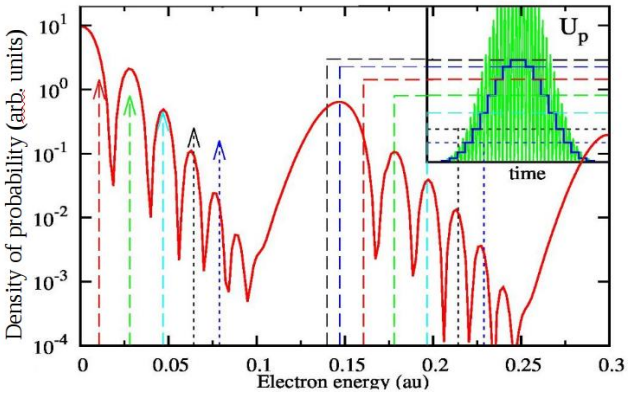

Figure 1. H($1s$) ATI differential ionization probability as function of photoelectron energy for a 24 cycles laser with frequency $\omega = 0.15$ a.u. [3].

[1] Della Picca R, Fiol J and Fainstein P D 2013 *J. Phys. B: At. Mol. Opt. Phys.* **46** 175603
[2] Della Picca R *et al* 2009 *Phys. Rev. A* **79** 032702. See also 2011 *Phys. Rev. A* **84** 033405
[3] Della Picca R *et al* 2016 *Phys. Rev. A* **93** 0323419