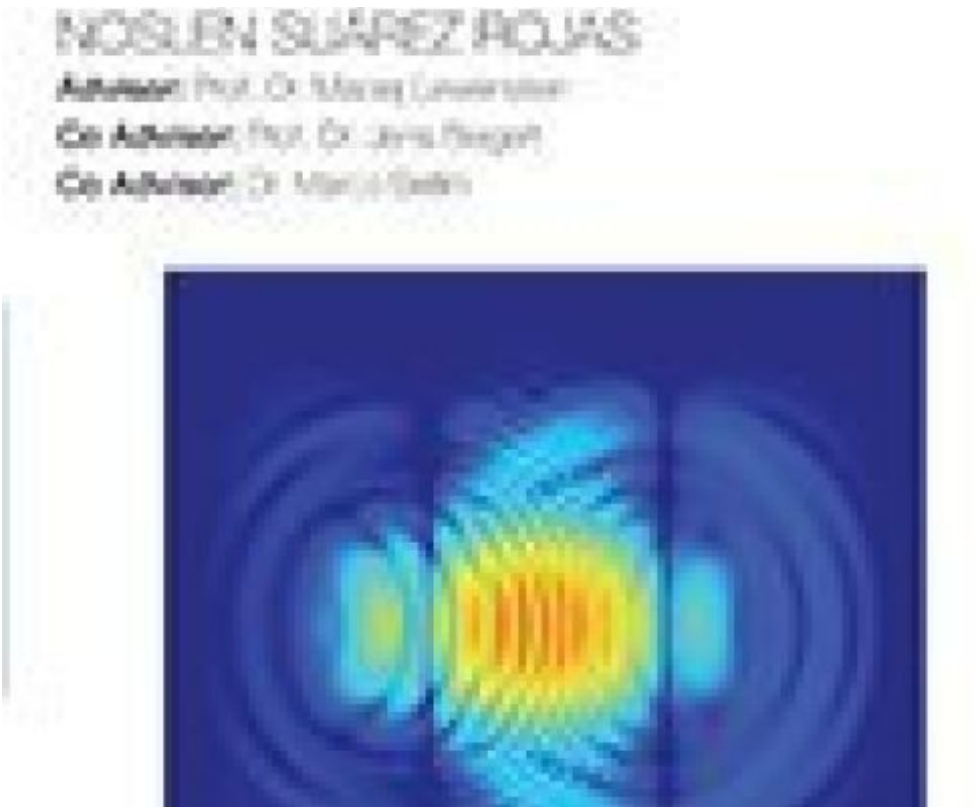

PhD Thesis Defense NOSLEN SUAREZ 'Strong-Field Processes in Atoms and Polyatomic Molecules'

NOSLEN SUAREZ

January 23, 2018

Tuesday, January 23, 11:00. ICFO Auditorium

NOSLEN SUAREZ

Quantum Optics Theory

ICFO-The Institute of Photonic Sciences

In this thesis, we develop a general theory to describe the dynamics of electrons that are ionized when an atom or molecule is exposed to a strong low frequency laser field. Our approach extends and improves the well-established theoretical strong-field approximation (SFA). Additionally, our modified strong field approximation (MSFA) can be extended in a natural way from atomic systems to a more complex molecules and multielectron systems.

Our scheme involves two innovative aspects: (i) First, the bound-continuum and rescattering matrix elements can be analytically computed for both atomic and multicenter molecular systems, using a nonlocal short range (SR), but separable, potential. When compared with the standard models, these analytical derivations make possible to directly examine how the ATI and HHG spectra depend on the driven media and laser-pulse features. Furthermore, our model allows us to disentangle the different processes contributing to the total spectra, amongst other capabilities, and it allows us to adjust both the internuclear separation and atomic or molecular potential in a direct and simple way. Furthermore, we can turn on and off contributions having distinct physical origins or corresponding to different mechanisms that correspond to (1) direct tunneling ionization; (2) electron escattering/recombining on the center of origin; and, finally, (3) electron rescattering/recombining on a different center. (ii) Second, the multicenter matrix elements in our theory are free from nonphysical coordinate-systemdependent terms; this is accomplished by adapting the coordinate system to the center from which the corresponding time-dependent wave function originates. Having established the basic formalism, we then study the HHG and ATI processes for a variety of atomic and molecular systems. We compare the SFA results with the full numerical solutions of the timedependent Schrodinger equation (TDSE), when available, within the few-cycle pulse regime. We show how our MSFA can be used to look inside the underlying physics of those phenomena. With our tool it is possible to investigate the interference features, ubiquitously present in every strong-field phenomenon involving a multicenter target, or to describe laser-induced electron diffraction (LIED) measurements retrieving molecular structural information from the photoelectron spectra. Our approach paves the way to study the HHG and ATI processes in much more complex molecular targets. Additionally, it potentially can be extended to study these kind of recombination and rescattering scenarios in solid targets.

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