# *Abstract*

**Engineering and Control of Quantum Processes by Short Laser Pulses**

by Felipe CAJIAO VÉLEZ

We study two of the most important phenomena in strong-field physics: ionization by intense laser pulses and high-order harmonic generation. For the former one, we develop the generalized eikonal approximation which includes the interaction between the ionized electron and its parent ion. In contrast to the original eikonal approximation, it avoids a singularity at the Coulomb potential centre. Thus, it can be successfully applied to analyze rescattering phenomena in terms of quantum trajectories. The latter one is treated according to the Lewenstein model, which ignores the interaction between the electron and the ion after it penetrates the Coulomb barrier and before it recombines. Nevertheless, the model describes the process in a good qualitative way.

Employing the generalized eikonal approximation, we study the coherent interference patterns in photoelectron energy spectra and their modifications induced by the interaction of photoelectrons with the atomic potential. As well, we analyze how different factors characterizing the laser pulse (such as modulations of the pulse envelope or a number of cycles) influence these structures. In other words, we demonstrate the possibility of controlling the process by an external laser field. On the other hand, the Lewenstein model is used to analyze the harmonic responses from the $C_{20}$ carbon clusters ($C_{20}$ fullerene and two of its isomers: ring and bowl) and the nitrogen molecule. We show that the harmonic spectra present well-defined modulations in the peak intensities, which are directly related to the geometry of the molecule and the symmetry of its electron orbitals. Multicentre interferences and quantum trajectories interference are the main sources of such modulations. Other properties, e.g., polarization of the harmonic response and harmonic ellipticity from nitrogen molecule, are also analyzed and related to the molecular structure. Finally, we discuss the prospects of using the harmonic spectra from molecules to develop a simple spectroscopic technique to identify their geometric configuration. As well, we discuss the application of the generalized eikonal approximation to study strong-field ionization from multicentre atomic systems and to study other strong-field phenomena.