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Attosecond Physics at the nanoscale: the next frontier

Dr. Marcelo Ciappina

ELI-Beamlines, Czech Republic

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Wiedner Hauptstr. 8, 1040 Vienna, Seminar room DB Gelb 10 (DB10E11), 10th floor.

Host: J. Burgdörfer

Abstract

Recently two, a priori, different branches of physics have started to merge. One is attosecond physics, that deals with, both theoretical and experimentally, the phenomena which take place when ultrashort laser pulses, with durations ranging from the attosecond to the femtosecond time scale, interact with atoms, molecules or solids. The laser-induced electron dynamics occurs natively at an attosecond time scale (1 attosecond=10-18 s), where e.g. the period of a classical electron in a hydrogen atom is 152 as) and consequently, the underlying physics requires tools employing attosecond time resolution (both in theory and experiments). This subject has reached great maturity on the basis of well-established theoretical developments and the understanding of different nonlinear phenomena, as well as thanks to the formidable advances in experimental techniques. Nowadays, for instance, measurements with attosecond precision are routinely performed in several facilities around the world.

The second branch involves the manipulation and engineering of mesoscopic systems, e.g. solids, metals, dielectrics, with nanometric precision, a scale that was only reached recently. In this way, it is possible to design and build bulk matter samples which pave the way to study light-matter interaction in a completely new regime.

In this seminar I'll summarize the theoretical work we have done to tackle the underlying physics of laser-matter processes driven by spatially and temporal synthesized fields, with a main emphasis in above-threshold ionization (ATI) and high-order harmonics generation (HHG) in atoms and molecules induced by plasmonic fields [1]. It is well known that one of the main theoretical assumptions in the modelling of laser-matter phenomena is that the laser electric field is spatially homogeneous in the region where the electron dynamics takes place. When we relax this premise, i.e. when the laser electric field presents variations at a nanometric scale, we open a new and unexplored scenario until now. By using classical, semiclassical and quantum mechanical theoretical tools we were able to shed some light about the modifications produced by spatially inhomogeneous fields - fields that present spatial variations in a scale comparable to the one of the electron dynamics. I will also discuss about the experimental challenges we face, in order to confirm our predictions, and alternative approaches we thought could be more plausible to implement. At the end of the talk I'll present a brief summary of other current and future projects.

[1] M. F. Ciappina, et al. Attosecond Physics at the nanoscale, Rep. Prog. Phys 80, 054401 (2017)

FWF Der Wissenschaftsfonds.

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