Beyond Carbon K-edge harmonic emission in He using a spatially and temporally synthesized laser field

M. F. Ciappina[1,2], J. A. Pérez-Hernández[3], M. Lewenstein[1,4], L. Roso[3], A. Zaïr[5]

[1]ICFO-Institut de Ciènces Fotòniques, Mediterranean Technology Park, 08860 Castelldefels (Barcelona), Spain
[2]Department of Physics, Auburn University, Auburn, Alabama 36849, USA
[3]Centro de Láseres Pulsados, CLPU, E-37008 Salamanca, Spain
[4]ICREA-Institució Catalana de Recerca i Estudis Avançats, Lluis Companys 23, 08010 Barcelona, Spain
[5]Department of Physics, Imperial College London, London, SW7 2AZ, United Kingdom
mfc0007@auburn.edu

We present numerical simulations of high-order harmonic generation (HHG) in helium atoms while subject to a temporally synthesized and spatially non-homogeneous strong laser field. The goal is to demonstrate that such combined synthesis allows us to free new degrees of the HHG process in order to provide KeV photon energies. In this purpose many strategies, involving laser field tailoring for HHG, have been implemented. Strategies based on a combination of multiple colours or chirping techniques have been proposed to temporally synthesize the strong laser field within an optical cycle hence controlling the electronic wave packet trajectories at the origin of the HHG process. In addition others approaches have been set up based on spatially synthesized a flat top laser for the generation of HHG continuum and so isolated attosecond pulses.

We investigate the case where both temporal and spatial synthesis are used together for HHG and address the question on how such synthesis may open new degree of freedom for the control of the HHG process. The temporal synthesis is realized using two identical few-cycle laser pulses delayed in time. The spatial synthesis is obtained by employing a spatial nonhomogeneous laser field [1,2,3] produced, for instance, by nano-plasmonic antennas. The combination of a laser field synthesized both spatially and temporally seems to allow a new control on electronic wave packet trajectories which one signature is the generation of coherent XUV photons beyond the carbon K-edge [4].

Our predictions are based on the convergence of three complementary theoretical approaches: (i) computing the harmonic spectrum by the resolution of the three dimensional Time Dependent Schrödinger Equation (ii) time-frequency analysis of the resulting dipole moment and (iii) classical trajectory extraction.

The results obtained show that the combination of spatial and temporal synthesis induces a selection of the most energetic electronic trajectories as the origin of the strong cut-off energy extension.

References:
[1] S. Kim, J. Jin, Y.-J. Kim, I.-Y. Park, Y. Kim and S.-W. Kim, Nature **453**, 07012 (2008).
[2] I.-Y. Park, S. Kim, J. Choi, D.-H. Lee, Y.-J. Kim, M. F. Kling, M.I .Stockman and S. W. Kim, Nat. Phot. **5**, 667 (2011).
[3] I. Yavuz, Phys. Rev. A **85**, 013416 (2012).
[4] J. A. Pérez-Hernández, M. F. Ciappina, M. Lewenstein, L. Roso, and A. Zaïr, Phys. Rev. Lett. **110**, 053001 (2013).