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High-harmonic generation on plasma mirrors in the λ^3 regime

A. Borot[1], A. Malvache[1], X. Chen[1, 2], P. Audebert[3], J.-P. Geindre[3], G. Mourou[2], M. Ivanov[4], R. Lopez-Martens[1,*]

[1] *Laboratoire d'Optique Appliquée*, ENSTA ParisTech ,Ecole Polytechnique, CNRS, 91761 Palaiseau Cédex, France
[2] *Institut de la Lumière Extrême*, CNRS, Ecole Polytechnique, ENSTA ParisTech, Institut d'Optique, Université Paris-Sud, Palaiseau, France
[3] *Laboratoire pour l'Utilisation des Lasers Intenses*, Ecole Polytechnique-CNRS, 91128 Palaiseau, France
[4] *Department of Physics*, Imperial College London, United Kingdom
*rodrigo.lopezmartens@ensta.fr, http://loa.ensta.fr/

High-harmonic generation from plasma mirrors driven by ultra-high intensity lasers is predicted to be a source of attosecond XUV pulses with shorter wavelengths and higher energies than those currently generated in gases [1]. To date, plasma mirror experiments have been carried out using high-peak power laser systems operating on a single-shot basis [2]. A much less explored regime consists using few-cycle pulses down to spot sizes comparable with the square of the laser wavelength, thus reaching relativistic intensities with milliJoule pulse energy. In this so-called λ^3 regime, one can envisage driving plasma mirrors with relativistic-intensity, fully CEP-controlled few-cycle pulses delivered by a compact kHz laser system, thereby offering the prospect of controlling the attosecond dynamics of relativistic plasma mirrors with unprecendented statistics.

Here, we report the first experimental demonstration of high-order harmonic generation from plasma mirrors driven at 1kHz repetition rate by milliJoule energy laser pulses at intensities up to 10^{18} W/cm^2. We observe characteristic coherent wake emission [3] from the overdense plasma produced on glass targets by CEP-controlled pulses with 1mJ energy and duration ranging from a 30fs down to a few optical cycles. The excellent shot-to-shot stability of our interaction conditions enables us to perform systematic parameter-dependence studies of the harmonic emission properties. From a fundamental point of view, the harmonic emission constitutes a powerful diagnostic of the complex laser-driven plasma dynamics: the spectral properties are determined by the attosecond dynamics of the Brunel electrons in the laser field as well as the femtosecond evolution of the plasma density gradient. We have developed a semi-analytical model in order to link the observed fine harmonic spectral features to the dynamics of the overdense plasma.

References:

1. Tsakiris *et al.*, *New J. Phys.* **8**, 19 (2006)
2. Dromey *et al.*, Nature Phys. **2**, 456 (2006); Tarasevitch *et al.*, Phys. Rev. Lett. **98**, 103902 (2007); Thaury *et al.*, Nature Phys. **3** 424 (2007)
3. Quéré *et al.*, Phys; Rev. Lett. **96**, 125004 (2006)