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High-order harmonics generation from overdense plasmas

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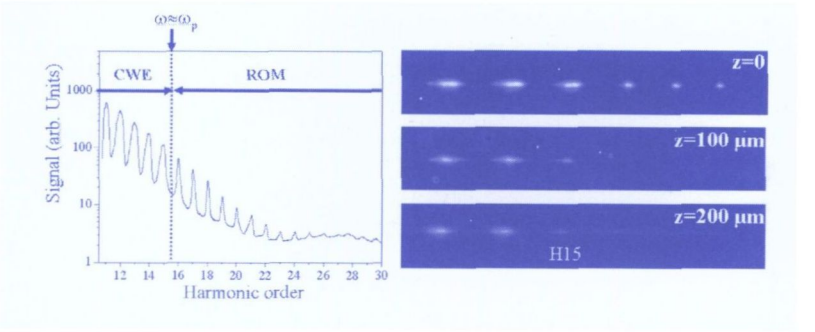
When an intense laser beam reflects on an overdense plasma generated on a solid target, high-order harmonics of the incident laser frequency are observed in the reflected beam (see [1] and ref. therein). This process provides a way to produce XUV femtosecond and attosecond pulses in the μJ range from ultrafast ultraintense lasers. Studying the mechanisms responsible for this harmonic emission is also of strong fundamental interest: just as HHG in gases has been instrumental in providing a comprehensive understanding of basic intense laser-atom interactions, HHG from solid-density plasmas is likely to become a unique tool to investigate many key features of laser-plasma interactions at high intensities.

We will present both experimental (see figure) and theoretical evidence that two mechanisms contribute to this harmonic emission :

- Coherent Wake Emission [2] : in this process, harmonics are emitted by plasma oscillations in the overdense plasma, triggered in the wake of jets of Brunel electrons [3] generated by the laser field.

- The relativistic oscillating mirror [4] : in this process, the intense laser field drives a relativistic oscillation of the plasma surface, which in turn gives rise to a periodic phase modulation of the reflected beam, and hence to the generation of harmonics of the incident frequency.



Left graph : experimental harmonic spectrum from a polypropylene target, obtained with 60 fs laser pulses at 10^{19} W/cm^2, with a very high temporal contrast (10^{10}). The plasma frequency of this target corresponds to harmonics 15-16, thus excluding the CWE mechanism for the generation of harmonics of higher orders. **Images on the right** : harmonic spectra from orders 13 et 18, for different distances z between the target and the best focus. At the highest intensity (z=0), harmonics emitted by the ROM mechanism are observed above the 15th order. These harmonics have a much smaller spectral width then those due to CWE

(below the 15th order). These ROM harmonics vanish as soon as the intensity is slightly decreased (z=100 μm), while the CWE harmonic persists even at lower intensities (z=200 μm).

[1] P.Monot et al, *Opt. Lett. 29 (2004), 893*
[2] F. Quéré et al, *Phys. Rev. Lett. 96 (2006), 125004*
[3] F. Brunel, *Phys. Rev. Lett. 59 (1987), 52*
[4] R. Lichters et al, *Phys. Plasmas 3 (1996), 3425*