HIGH-ORDER HARMONIC GENERATION FROM PLASMA MIRRORS

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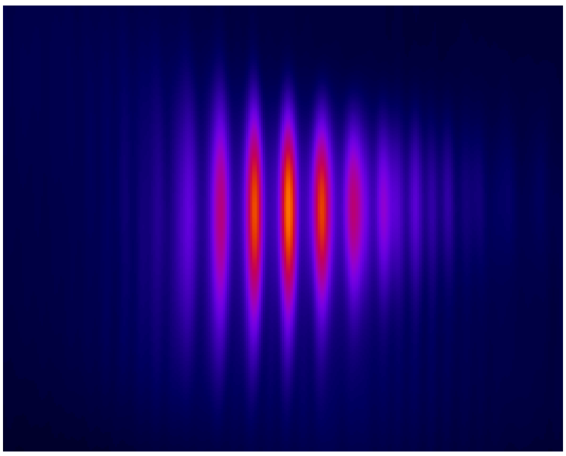
When an intense laser pulse impinges a solid target, it creates a dense plasma at its surface. During an ultrashort laser pulse—typically below 100 fs—this plasma only expands by a small fraction of the light wavelength, and thus behaves as a high-flatness mirror, called a plasma mirror. In appropriate interaction conditions, high-order harmonics of the incident laser frequency are observed in the beam reflected by such a plasma mirror. This process should provide 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 plasma mirrors is likely to become a unique tool to investigate many key features of laser-plasma interactions at high intensities.

We will present both experimental and theoretical evidence that two mechanisms can lead to harmonic emission from plasma mirrors [1] :

- Coherent Wake Emission [2] : in this process, harmonics are emitted by plasma oscillations excited in the sharp density gradient at the interface between the overdense plasma and vacuum. These plasma oscillations are 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 mirror surface. This oscillating mirror in turn gives rise to a periodic phase modulation of the reflected beam, and hence to the generation of harmonics of the incident frequency.

The second part of the talk will be devoted to a discussion of the properties of CWE harmonics. We demonstrate experimentally that CWE harmonics have an intensity-dependent intrinsic phase, which, according to PIC simulations, is directly related to the dynamics of Brunel electrons. Lastly, we will present the first experimental evidence of the mutual coherence of several harmonic sources from a plasma mirror (figure below), a result that proves the coherence of the CWE mechanism.



Far-field interference pattern of three independent harmonic sources from a plasma mirror.

[1] C.Thaury *et al*, *Nature Physics 3 (2007) 424 - 429*
[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*