

Research Topic for the ParisTech/CSC PhD Program
(one page maximum)

***Field (cf. List of fields below):** Physics, Optics

Subfield: Ultrafast Optics

Title: Generation of single-cycle laser pulses and study of their interaction with a plasma mirror

ParisTech School: ENSTA

Advisor(s) Name: Rodrigo Lopez-Martens, Stefan Haessler

Advisor(s) Email: rodrigo.lopez-martens@ensta-paristech.fr, stefan.haessler@ensta-paristech.fr

(Lab, website): <http://loa.ensta-paristech.fr/pco/>

Short description of possible research topics for a PhD:

Femtosecond laser pulses allow examining matter under extreme conditions. We are particularly interested in the collective electron dynamics driven in plasmas by the light-field oscillations of pulses whose duration approaches a single optical cycle (≈ 3 fs). These dynamics become spectacular when the laser field reaches intensities beyond 10^{18} W/cm²: the oscillating electrons are then accelerated to relativistic velocities, $\approx c$, in a fraction of the optical cycle. This relativistic regime of laser-plasma interaction is of great academic and technological interest and motivates the development of ever more powerful (petawatt) lasers. We focus on the development of smaller lasers with post-compression technology that allow accessing this regime with near-single-cycle pulses at high (kHz) repetition rate. These cutting-edge lasers then drive laser-plasma-interaction experiments on solid surfaces, in particular in the relativistic regime where the plasma becomes a secondary source of (attosecond) high-harmonic emission as well as ultrashort bunches of accelerated electrons and ions. Students can work on the laser technology development, the secondary-source development, as well as fundamental aspects of laser-driven plasma dynamics, both in the experiment and in simulations.

Required background of the student:

The candidate should have a solid background in physics, most importantly in optics. Previous practical experience in an ultra-fast optics laboratory would be greatly appreciated. A strong bias towards patient and precise practical lab-work with the joy of playing with technology would be ideal.

A list of 5(max.) representative publications of the group: (Related to the research topic)

1. Böhle, F. *et al.* Compression of CEP-stable multi-mJ laser pulses down to 4 fs in long hollow fibers. *Laser Physics Letters* **11**, 095401 (2014)
2. Borot, A. *et al.* High repetition rate plasma mirror device for attosecond science. *Review of Scientific Instruments* **85**, 013104 (2014)
3. Jacqmin, H. *et al.* Passive coherent combining of CEP-stable few-cycle pulses from a temporally divided hollow fiber compressor. *Opt. Lett.* **40**, 709–712 (2015).
4. Wheeler, J. A. *et al.* Attosecond lighthouses from plasma mirrors. *Nature Photonics* **6**, 829–833 (2012)
5. Kühn, S. *et al.* The ELI-ALPS facility: the next generation of attosecond sources. *J. Phys. B: At. Mol. Opt. Phys.* **50**, 132002 (2017)