Title : Intense attosecond light pulses from a relativistic plasma mirror

First Name : Stefan	**Name :** HAESSLER	**Laboratory :** LOA

Email : stefan.haessler@cnrs.fr

Webpage : https://loa.ensta-paris.fr/research/pco-research-group/

Research Area : Laser-plasma physics, Optics, Attosecond physics, Ultra-high intensity interactions

Methods : High-power femtosecond laser system, nonlinear optics, plasma mirrors, plasma diagnostics, XUV diagnostics, time-of-flight spectrometry

PhD track subject:

Light pulses of attosecond duration (10^{-18} s) are the fastest tool that mankind has developed so far. Producing such pulses at with high power and focusing them to higher and higher intensity is a major research direction that will give access to ever more extreme conditions.

In the PCO-group of LOA, we run a unique home-built laser-system [1] that generates pulses with terawatt peak power at 1 kHz repetition rate, lasting <4 fs, i.e. less than two periods than its light-wave oscillation cycles. This drives a so-called relativistic plasma-mirror [2], a dense surface-plasma on a solid target, which reflects the incident laser. This device is not only a beautiful model system for studying relativistic laser-plasma interaction, but it also compresses the reflected laser pulses to attosecond duration through surface high-harmonic generation (SHHGà. Their spectrum then spans the whole visible range and into the XUV.

Focusing such pulses to high intensity is a challenge because optical aberrations very quickly degrade their spatio-temporal quality [3]. In the next few years, we will tackle this challenge and aim at demonstrating the highest light intensity ever generated by attosecond pulses in a detector.

We are looking for a motivated student for a Master's thesis and subsequent PhD to join us in this effort. This mainly experimental work touches several areas of physics: optimization of the generated SHHG power and the spatial quality of the reflected beam (=laser-plasma interaction physics), the design, implementation and validation of suitable refocusing optics (=ultrafast XUV optics), and finally the demonstration of high achieved intensities in a photo-electron/ion detector (=strong-field atomic physics on attosecond time scale). Theoretically inclined students can also find ample opportunity simulations, both of classical plasma dynamics and of quantum dynamics on the atomic scale.

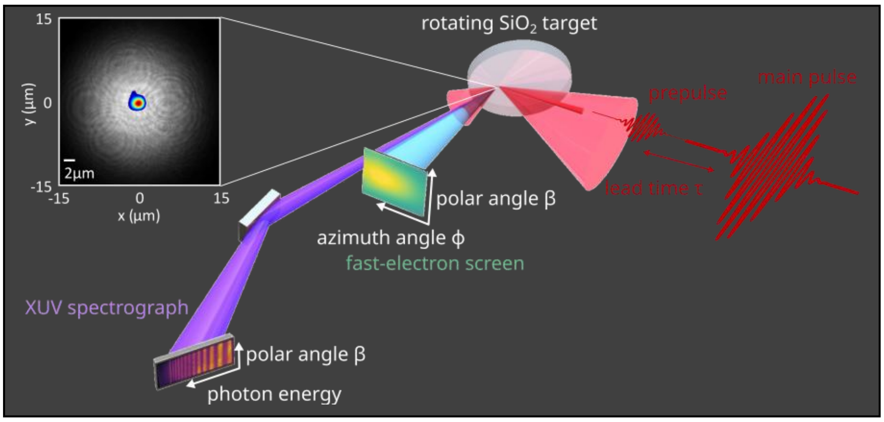

Illustration the current plasma-mirror setup with detection of XUV light and accelerated electrons.

References:

[1] M. Ouillé *et al.*, Relativistic-Intensity Near-Single-Cycle Light Waveforms at kHz Repetition Rate, *Light Sci. Appl.* **9**, 1 (2020).

[2] S. Haessler *et al.*, High-Harmonic Generation and Correlated Electron Emission from Relativistic Plasma Mirrors at 1 kHz Repetition Rate, *Ultrafast Science* **2022**, 9893418 (2022).

[3] C. Bourassin-Bouchet et al., *How to Focus an Attosecond Pulse*, Opt. Express **21**, 2506 (2013).