Master 2 “Photonics, Complex and Quantum Systems (PhoCQS)”: Research Training 2023-2024

Supervisor: Serge Bielawski

Topic: Dynamics of complex systems (in accelerator based light sources)

« Terahertz oscilloscopes » based on photonic time-stretch concepts

This Master 2 research subject is at the intersection between fundamental and applied physics. Recording electromagnetic signals in real-time and high speed (for instance realizing oscilloscopes with THz bandwidth) is a largely open problem. Recording ultrafast signals is moreover needed in a range of situations including accelerator physics, fast THz spectroscopy, and Free-Electron Lasers, etc.

Recently, several key concepts (such as photonic time-stretch, time-holography and information diversity) opened the way to the realization of such ultrafast recording systems. The principle consists of probing the signals of interest using femtosecond lasers, and analyzing the modified laser pulses. As a key point, the strategy combines ultrafast photonic hardware, with advanced numerical algorithms (see, e.g., Ref. [1]). On this ultrafast measurement subject, the PhLAM laboratory is at the center of a collaboration network including several accelerator facilities (including SOLEIL in France, DESY, the FELBE Free-Electron Laser, and the MLS electron storage ring in Germany), and several photonics laboratories.

The Master research subject will aim at finding new ideas for pushing further the performance in terms of speed and/or sensitivity of ultrafast “real-time” measurement systems, so that new application ranges become possible. Foreseen applications include relativistic electron bunch shapes at an accelerator, the light emitted by free-electron lasers, or to a novel table-top spectroscopy experiment. Of course, the interested student will not start from scratch, and will benefit from the knowledge present at PhLAM, including previously realized experiments and algorithms. The internship will start by a bibliographic study and training on the existing concepts and techniques for ultrafast recordings, and on the needs in accelerator (and classical) physics. The intership will be followed by the realization of a novel real-time photonic measurement system with THz bandwidth.

The internship will require to work in an international environment (implying a taste for communication in English), and a good level in Pyhon programming.

Key words: accelerators physics, photonics, numerical and experimental studies

[1] Phase Diversity Electro-optic Sampling: A new approach to single-shot terahertz waveform recording, E. Roussel et al., Light: Science & Applications volume 11, Article number: 14 (2022) https://www.nature.com/articles/s41377-021-00696-2