Master 2 “Photonics, Complex and Quantum Systems (PhoCQS)”: Research Training 2025-2026

Appel à sujet de stage recherche / Call for research training subject

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Topic: Free-Electron Laser

Master 2: select the master and the most appropriate option

□ Master 2 PhoCQS (GP-IKS)	
□ Option Complex and Quantum Systems	

Title: **Generating and preserving electron-beam modulations in a linear accelerator for coherent THz generation**

Radiation sources based on accelerated electron, such as free-electron lasers (FELs), are now essential for generating extreme-wavelength radiation—including terahertz (THz), extreme ultraviolet (EUV), and X-rays. Coherent transition radiation (CTR) is emitted when a metal foil intersects the path of an electron bunch, and its spectral content directly reflects the temporal and spectral properties of that bunch.

A possible strategy to control the spectral content of the generated THz radiation is to imprint a charge density modulation onto the electron beam at a frequency linked to the desired THz output. This can be achieved through the interaction of the beam with an external laser in beating mode during an early stage of the acceleration process. However, a major challenge remains: preserving this modulation all the way down to the CTR source at the end of the FEL line.

This Master’s internship will focus on a numerical investigation of the dynamics of a modulated electron beam in the FERMI free-electron laser* (Elettra Sincrotrone Trieste, Italy). The project will use established simulation codes to model electron bunch dynamics under laser beating, with the goal of generating coherent, monochromatic THz radiation. Prior programming experience is required, along with proficiency in tools such as Python, C/C++, and Linux. Computations will be carried out on the PhLAM laboratory’s high-performance computing cluster, and the results may be benchmarked against experimental data from measurement campaigns at FERMI FEL.

* https://www.elettra.eu/lightsources/fermi.html

Key words: Linear Accelerator; Coherent THz generation; Free-Electron laser