TOWARD COHERENT ULTRAFAST TRANSMISSION ELECTRON MICROSCOPY

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Application deadline: July 2015 (interested candidates are strongly encouraged to contact us as soon as possible)

CONTEXT: Investigation of the physics of nanostructures requires nanometer or atomic spatial resolution, meV spectral resolution and femto to nanosecond time-resolution. Accessing all these informations simultaneously would be a breakthrough in nanophysics. However, up to now, no technique offers this unique combination of performances. Ultrafast Transmission Electron Microscopes (UTEM) combining sub-picosecond temporal resolution and nanometer spatial resolution have very recently emerged as unique tools for investigations at both ultimate spatial and temporal resolutions. However, the performances of state-of-the-art UTEM are in practice limitating the spatial resolution to tens to hundreds of nanometers – unfortunately, larger than the lengthscale of most of the relevant nanophysics phenomena.

ABSTRACT: The FemTOTEM project aims at developing an alternative Ultrafast Transmission Electron Microscope based on a high brightness laser-driven field emission electron source working under 200kV acceleration voltage. The latter consists of a metallic nanotip illuminated by femtosecond laser pulses. This development will be achieved by bringing together a femtosecond laser source and a customized 200kV cold-field emission Transmission Electron Microscope (CFE-TEM). This unique combination of femtosecond time resolution and high brightness (allowing an optimization between probe current and spatial coherence) will have an unrivalled potential for frontier research in nanophysics and fundamental science. This development will enable fast electron based nanospectroscopies and lead to the first time-resolved electron holography experiments. Its 4 major objectives are:

- *Picosecond Time-Resolved Cathodoluminescence (pTRCL) studies of the carrier dynamics in semi-conductor nanostructures at the nanometer scale.*
- *Electron Energy Gain Spectroscopy (EEGS) of plasmonic and photonic nanosystems*

- *Ultrafast electron holography*
- *Ultrafast electron diffraction*

This project is mostly experimental. The first objective of this thesis is the finalization of the development of the ultrafast Transmission Electron Microscope and the complete characterization of its performances (probe current, brightness, spatial, spectral and temporal resolutions). The second objective is the demonstration of its potential first on routine (static) electron microscopy experiments and then on the new experiments listed above. First, Cathodoluminescence experiments will be performed on semiconductor nanostructures to investigate the electron dynamics in quantum confined nanostructures with nanometer scale resolution. Second, Electron Energy Gain spectroscopy will be used to gain insight into the properties of plasmonic and photonic nanostructures at ultimate spatial and spectral resolution. Finally, the last objective of this thesis is the realization of ultrafast electron holography experiments.

An important part of this thesis will also be dedicated to the modeling of various aspects of the experiments involving optical excitation and ultrashort electron pulses (generation, propagation and characterization of ultrashort electron pulses, interaction of ultrashort electron pulses with an optically excited nano-object).

Candidate Profile : The PhD candidate should have a Master's degree (or comparable) in physics, solid state physics, optics, nonlinear optics or quantum mechanics. He/she will also have a taste for demanding experiments. It is requested to provide a detailed CV with any application.

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