Matter dynamics in extreme conditions; Generation of non-equilibrium states using ultrashort engineered laser beams

Laboratoire Hubert Curien, CNRS UMR 5516 Université Jean Monnet, Saint Etienne/Optics &nd Photonics Department / Laser-mater interaction Group

The "Optics and Photonics" department (Laser-matter interaction group) at the Laboratoire Hubert Curien, CNRS UMR 5516, Jean Monnet University in Saint Etienne, France, is currently seeking a doctoral candidate for its research activities. Applications are invited for a doctoral position that will open in October 2019. The position is limited to three years.

Environment: Hubert Curien Laboratory is a mixed research unit, jointly run by the "Centre National de la Recherche Scientifique - CNRS" and the Jean Monnet University. The proposed subject concerns ultrafast laser-assisted transformation of bulk optical materials on micro- and nano-scales. The Ultrafast laser platform located at the Hubert Curien Laboratory hosts state-of-the-art equipment for beam engineering, laser processing, and process characterization.

Project: Defining matter characteristics at structural levels is key for designing materials and advanced functions. To this, ultrafast laser-induced extreme conditions of pressure and temperature in bulk materials are favorable to the synthesis of novel extraordinary phases via potential creation of non-equilibrium warm-dense-matter or strong shocks, but also for developing volume integrated optical micro-nano-systems based on 3D refractive index changes. To this end we propose new concepts of spatio-temporal beam engineering to optimize energy deposition and time-resolved techniques to observe the dynamics of material transformation in silica. This is of interest in view of its technology potential but equally, its fundamental interest as marker in geophysical high-energy interactions.

Objective: The activity will focus on the achievement of extreme states with record thermodynamic parameters and evolution controllable in space and time, toward new superdense phases in silica materials. Combining ultrafast non-equilibrium and strong thermo-mechanical constraints, it aims at identifying the drive forces using space-time design of irradiation sources and dynamic observation and simulation of structural dynamics. We expect significant gain in understanding material behaviors in extreme conditions and strong deformation yields.

Job description. The PhD thesis project proposes a scientific introspection into the fundamental mechanisms of laser material modification by studying their dynamics. For this aim, a range of time-resolved (pump-probe) laser-based approaches will be developed via direct or spectral imaging in visible domains, time-resolved quantitative phase contrast microscopy, and THz Time-domain probing of the transient anisotropic dielectric function. In particular, one of the main goals of the PhD project is to show the potential of THz Time-Domain Spectroscopy for studying the matter dynamics induced by focused ultrashort laser pulses in bulk glasses. For this purpose the recruited PhD student will set-up a THz Time-Domaine spectroscopy platform in order to obtain the THz pulses, which will be used as a probe. In parallel techniques of beam engineering would be applied to control and optimize laser interaction, notably time-shaped non-diffractive concepts to be implemented with pump-probe experiments.

Candidate profile. We are looking for a highly motivated PhD student, with a strong interest in fundamental and experimental physics and a strong background in optics. Experience in developing optical systems and in the utilizations of lasers is a plus. Candidates should have a MSc degree (or equivalent) in physics or engineering, and show interest for interdisciplinary work in the field of laser-material interactions. The application should be supported by sound academic records and recommendation letters. Expertise is required in the following areas: ultrafast laser-material interactions, condensed matter, microscopy, solid-state physics, spectroscopy, ultrafast optics, linear and nonlinear optics, laser-induced ultrafast phenomena, and photonics. Programming skills and a good command of English are also required.

Payment: Fellowship of the Ministry of Education and of the Gradual School of St. Etienne

Duration: 36 months, **Application Deadline:** 01/04/2019

Contact (with customary documents: CV, letter of intent, recommendation letters.)**.** Academic transcripts should be made available upon request.

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Note: The Laboratoire Hubert Curien is a restricted access area. The fellowship is conditioned by the security clearance, to be applied during the PhD application.