PhD track Master internship:

Spatiotemporal shaping of ultrafast laser-induced shockwaves

Laboratory: LP3, Campus de Luminy, Marseille 13009, France
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Keywords: ultrafast physics, ultrashort laser pulse, laser beam shaping, shockwave
Monthly allowance: ~630 €/month
Duration: 6 months
Starting date: 1st quarter 2024

Description: Today, we use lasers to generate conditions similar to those in hot cores of stars and planets on a tabletop optical experiment. To do so, we employ ultrashort laser pulses capable of generating extremely high optical intensities in the 10^{14} W/cm^2 range. At such intensities, an initially-transparent material transforms locally into a dense plasma. Strong pressure-temperature gradients build up inside the volume of the irradiated area that result in a violent decompression through emission of a shockwave [1]. Stress generated by the passage of the shockwave inside a material may permanently change its structure and laser-transform it in a new denser phase. A plethora of novel applications would then become possible (MEMS, MOEMS etc.) within a direct microfabrication technique with 3D abilities.

The object of this internship is to investigate different ways of controlling laser-generated shockwave propagation in glasses. To do so, the student will explore laser beam shaping techniques based on the spatiotemporal modulation of the laser field. Fixed phase plates will be used first to Bessel-Vortex transform a gaussian beam. A first demonstration will be the obtention of controlled hollow cylinder-shaped modifications inside the bulk of a fused silica glass sample. We will then seek for increased flexibility on the beam shaping by implementing a commercial spatial light modulator to allow precise control over the Bessel-Vortex ring thickness and diameter. Finally, we will characterize the resulting shockwave by time-resolved optical microscopy. The recruited student will use an existing setup at LP3 as a starting block that is used for the generation and characterization of Bessel beams [2]. This setup uses the ASUR laser facility at LP3 delivering infrared (λ=800 nm) pulses with 30 fs pulse duration and a pulse energy of 15 mJ.

This project is an excellent opportunity to develop skills in a multidisciplinary field of Physics (Plasma Physics, Lasers, Thermodynamics, Mechanics etc.) and engineering. The student should have a strong background in Optics and/or Materials Science. A taste for experimental physics is necessary. Depending on the outcome, the recruited student may benefit from acquired funding for conducting a PhD study on the subject.

[1] O. Koritsoglou, D. Loison, O. Uteza, and A. Mouskeftaras, "Characteristics of femtosecond laser-induced shockwaves in air," *Opt. Express*, vol. 30, no. 21, p. 37407, 2022.

[2] X. Liu, R. Clady, D. Grojo, O. Utéza, and N. Sanner, "Engraving Depth-Controlled Nanohole Arrays on Fused Silica by Direct Short-Pulse Laser Ablation," *Adv. Mater. Interfaces*, vol. 2202189, p. 2202189, 2023.