Lab project M2 PPN

Monday & Tuesday from Oct 2025 to March 2026

Title of the project: Theoretical and numerical investigation of the Pi-FROST characterization method

Supervisor(s): Pierre Béjot/Edouard Hertz

Laboratory / Department / Team : ICB/Photonic Deparment/Processus Femtosecond et Laser Intense (PFL)

Collaborations: X

Summary:

The Plasma-induced Frequency Resolved Optical SwiTching (Pi-FROST) is a novel technic developed in the laboratory aiming at characterizing the temporal waveform of ultrashort laser. This recently method allows for a temporal reconstruction of a pulse at its focal spot by utilizing a moderately intense pump laser pulse for generating an ionization-induced ultrafast defocusing lens. When propagating through the produced plasma lens, the probe beam to characterize experiences an increase of its size in the far field. The spectrum of the defocused probe field, measured as a function of the pump-probe delay, allows for a comprehensive characterization of the temporal and spectral attributes of the pulse.

The goal of this lab project is to theoretically and numerically study this technique which has been recently developed in the laboratory[1,2,3]. The student will develop a numerical code, based on the Unidirectional Pulse Propagation Equation (UUPE), mimicking the experiment so as to test its inherent limit (in terms of minimal pulse duration, spectral range…).

Initially tested in gazes, the student will also participate to the experiment aiming at testing the possibility to use a bulk material as a nonlinear medium.

The student should have some knowledge in nonlinear Optics. An experience in coding with Matlab will be appreciated

[1] R. Bhalavi, P. Béjot, A. Leblanc, A. Dubrouil, F. Billard, O. Faucher, and E. Hertz, *Phase-matching-free ultrashort laser pulse characterization from transient plasma lens*, Opt. Lett **49** (5), 1321-1324 (2024)

[2] P. Béjot, R.K. Bhalavi, A. Leblanc, A. Dubrouil, F. Billard, O. Faucher, and E. Hertz, Temporal characterization of laser pulses using an air-based knife-edge technique, Adv. Phot. Res. 6(1) 2400074 (2025)

[3] P. Béjot, B. Kiss, R. Shrestha, L. Abrok, Z. Kis, K. Pirisi, B. Bago, O. Faucher, F. Billard, E. Cormier, and E. Hertz, PI-FROSt characterization of solid-state harmonics with spectra spanning over 2.6 octaves, Optics & Laser Technology 190, 113039 (2025)

Type of project (theory / experiment): Both (but mainly theoretical)

Required skills: Matlab/Electromagnetism/ Nonlinear Optics