Effect of a background magnetic field on the processes responsible for type-III radio bursts in laser-plasma experiments

Laboratory astrophysics is a very active and fast developing field of plasma physics that aims at recreating, in the laboratory, conditions relevant to space physics or astrophysics.

Of particular importance for the proposed traineeship are the recent experimental efforts that have allowed to develop a new experimental platform [1], based on laser-plasma interaction, to explore the fundamental processes of wave coupling at the origin of interplanetary radio emissions [2,3]. Two experimental campaigns were carried out on the nanosecond kiloJoule-level laser facility LULI2000 at the Laboratoire d'Utilisation des Lasers Intenses (LULI, UMR7605) at Ecole Polytechnique. These experiments focused on reproducing the processes identified as responsible for type-III radio bursts emitted at twice the electron plasma frequency ($2\omega_p$) under conditions relevant to near-Earth orbit. Observed during solar bursts these electromagnetic emissions are thought to result from the coalescence of two Langmuir waves (LWs). In the interplanetary medium, the first LW is excited by electron beams, while the second is generated by electrostatic decay of Langmuir waves. In our experiments, instead of an electron beam, an energetic laser propagating through a plasma excited the primary LW. The EM radiation at $2\omega_p$ was then observed at different angles, its intensity, spectral evolution, and polarization confirming the LW-coalescence scenario.

Even though the plasma parameters for the LW in the experiment closely mimicked those found in the solar wind at near-Earth orbit, the plasma was not magnetized.

Space-relevant magnetizations ($\Omega_{ce}/\omega_p \sim 0.01$) could be, in principle, achieved using fields of a few tens of Tesla, available from pulsed coils or capacitive coils irradiated by a high-intensity pulsed laser. But to plan such an experiment, in-depth theoretical studies on the effect of a background magnetic field on the various processes at play in the experiment (stimulated Raman scattering, two plasmon coalescence, etc) need to be conducted. These theoretical studies need also to be supported by kinetic simulations. The trainee will thus be invested in both theoretical developments and kinetic simulations. The latter will be performed using the open-source Particle-In-Cell (PIC) code SMILEI [4], currently development at LULI in collaboration with various laboratories on the Plateau de Saclay and simulation experts from Maison de la Simulation.

These developments will help design a future experiment that will extend the platform already developed to account for an external magnetic field.

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