Title : **Innovative concepts for particles plasma acceleration and radiation emission in laser – overdense plasma interaction at ultra-high intensity**

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Research Area : Lasers and Plasma Physics

Methods: Particle-In-Cell Simulation

PhD track subject : The possibility of developing new compact energetic particle and radiation sources via several mechanisms involving the interaction of an ultra-intense laser (above 10^{19} W/cm^2) and plasmas has gained importance in the last decades. Different acceleration patterns were explored and electron beams from 1 to 20pC at energies of the order of GeV were obtained. The production of fast electron beams in the context of laser-solid interaction in the relativistic regime and heating of solid targets are of great interest, owing to the potential applications in the fast ignition scheme. Furthermore, the advent of Multi-PW laser allows to access ultra-relativistic intensities and extend the theory to include the possibility of pair creation via the interaction of fast electrons with the Coulomb field of high Z ions in a plasma or solid. In this context, significant effort is made to increase the coupling between the laser and the target, which remains weak at very high intensity and short pulse duration regimes. Thought a collaborative work, LSI and LULI teams explore the possibility to achieve increased laser absorption, XUV emission or fast electron production using targets with structured surfaces at the nanoscale or micrometer scale. The proposed work aims at exploring the ultra-relativistic regime (above 10^{21} W/cm^2) both theoretically and numerically looking for new advanced mechanism of laser over-dense plasma interaction where local fields more intense than the laser field can be created during excitation inducing nonlinear and relativistic effects. It is a major challenge to improve the quality of the beams of particles produced, electrons and ions, for later applications (free electron laser, production of X-ray or UV radiation). It is also of fundamental interest and may lead to groundbreaking ultra-short synchronized light and electron sources. In this context, the conditions to enhance the control of the produced particle beams to obtain narrow, monochromatic, energy spectra will be investigated. The simulations will be run with the Smilei PIC code. Smilei is a massively parallelized code that solves Vlasov equations coupled with Maxwell's equations on a Yee mesh which was developed to include ultra-high intensity laser physical effects. The candidate will be involved in the collaboration with C. Riconda et M. Grech (team TIPS/LULI) who initiated the development of the SMILEI code.

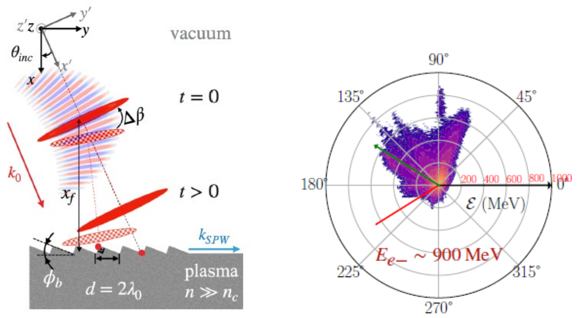

Figure: Tailored blazed grating and laser with wavefront rotation (left) and corresponding electron bunches distribution along the surface (right)

References :

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