Laser-Driven Intense Terahertz Fields

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Terahertz pulses are very popular because of their numerous applications, for example in security screening, medical imaging, time-domain spectroscopy and remote detection [1]. Located between microwaves and optical waves in the electromagnetic spectrum, terahertz waves can now be exploited in molecular spectroscopy from plasma emitters produced by femtosecond laser pulses ionizing gases such as air.

At non-relativistic laser intensities, gas plasmas created by two-color optical pulses supply suitable emitters free of any damage. Electrons are tunnel ionized by the asymmetric light field usually composed of a fundamental wavelength and its second harmonic [2]. The resulting "photocurrent" generates an ultrabroadband terahertz radiation, which finds direct applications in the coherent spectroscopy of complex molecules [3,4]. At relativistic intensities, plasma waves are characterized by a nonlinear longitudinal field used in laser-wakefield acceleration. Accelerated electrons crossing the plasma-vacuum interface then emit coherent transition radiation operating in the terahertz band [5,6].

This talk will review the different physical mechanisms involved in the terahertz emission by laser-gas interaction at moderate or relativistic intensity. First, recent results on plasma-based THz spectroscopy of crystal powders will be presented in the context of the project ALTESSE. Second, new perspectives in the production of ultra-intense terahertz pulses from electron acceleration in relativistic plasmas will be discussed. Finally, THz radiation originating from the ponderomotively-driven electron dynamics in strongly magnetized plasmas [7,8] will be addressed.

Particle-in-cell simulations will display evidence that THz pulses transmitted in this regime can reach field strengths > 100 GV/m and allow laser-to-THz conversion efficiencies exceeding 2‰ by adjusting the B-field strength and the background electron plasma density.

References

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