Terahertz pulse generation by laser-created plasmas

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Abstract:

Terahertz (THz) waves are nowadays very popular because of their numerous applications, for example in security screening, medical imaging, time-domain spectroscopy and remote detection. At non-relativistic laser intensities, air plasmas created by two-color optical pulses supply suitable THz emitters free of any damage. Their "photocurrents" generate ultrabroadband terahertz radiations which find direct applications in the coherent spectroscopy of macromolecules. At relativistic intensities, gas plasmas develop nonlinear electrostatic fields used in laser-wakefield particle acceleration. Accelerated electrons crossing the plasma-vacuum interface then emit coherent transition radiation (CTR) associated with tens of GV/m THz field amplitude and mJ energy. CTR also operates in relativistic laser-solid interactions, whereby it benefits from a stronger absorption of the laser energy into MeV-range electrons. Yet, the hot-electron population does not only radiate via CTR when exiting a solid foil. Less energetic electrons actually get reflected in the strong charge-separation field set up in vacuum. This results in an additional coherent, synchrotron-type radiation of polarity opposite to that of CTR. Moreover, the sheath electric field induced by the hot electrons subsequently sets into motion the surface ions over picosecond timescales and lead to a dipole-type, low-frequency radiation contributing to the THz spectrum.

This talk will first address the key role of photocurrents in the creation of broadband terahertz pulses at moderate laser intensities. Recent experimental results on plasma-based THz molecular spectroscopy will be discussed. Using multi-dimensional particle-in-cell simulations we will next present new perspectives in the production of ultra-intense terahertz pulses from particle acceleration in relativistic plasmas created from gaseous and solid targets.