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Laser-plasma mechanisms of generation THz radiation

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We report on both theoretical study and simulation of the terahertz (THz) electromagnetic pulse excitation during intense laser interaction with solid targets. Several mechanisms of THz broadband wave generation are proposed. Conversion efficiencies of laser radiation into THz electromagnetic pulse for these mechanisms have been compared. Surface and volumetric THz waves generated from different targets have been considered.

1. Introduction

Terahertz (THz) electromagnetic radiation has useful features for a number of applications such as diagnostic, scanning, security and communications. An intense laser -solid target interaction is promising and poorly investigated THz radiation source which may leads to high energy conversion efficiency from laser to THz pulse ~10^{-3} [1] and to high pulse energy. It has no any thresholds for energy of initial laser pulse which means that no energy limits for a resulting THz pulse. Several mechanisms of generation of the THz pulses, e.g. radiation generation during sheath acceleration process at the target rear surface [2] or THz emission by electrical current of fast electrons escaping a target [3] have been proposed. We report theoretical and numerical comparison of three different mechanisms of THz radiation generation from the laser plasma sources [4,5].

2. Results

The theory of THz radiation generated due to escape of hot electrons, plasma expansion into vacuum [4] and thermo current [5] is developed. Contributions of different laser-induced electron currents to the volumetric and surface THz pulses have been found. It has been shown that energy conversion efficiency from laser to volumetric THz radiation may reach 10^{-3} for escaping high-energy electrons. The near-surface thermoelectric mechanism and plasma expansion into a vacuum are less effective for THz generation.

Analytical theory demonstrates rather sharp increase of laser-THz pulse conversion efficiency with laser intensity and its linear growth with laser pulse duration. It also has been found that THz radiation generation is more efficient for laser tight focusing. Efficiency of surface waves excitation is at least order of magnitude less than that for volumetric ones. Along with this, surface THz pulses *are better suited for concentration and collimation of wave energy.* Surface wave may propagate along metal surface for a long distance due to its low divergence and attenuation. Propagation of Sommerfeld wave along metal wire and similar waveguide modes can be used for electron and ion guiding and acceleration.

Numerical simulations have been performed with FDTD method by using VSim code [5]. They well confirm analytical results and, in addition, demonstrate Sommerfeld pulse enhancement at conical wire target.

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