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Single-shot characterization of intense laser-driven terahertz radiation and its applications in laser-plasma diagnostics

Guoqian Liao, Fangzheng Sun, Hongyi Lei, Yutong Li
Institute of Physics, Chinese Academy of Sciences
e-mail (speaker): gqliao@iphy.ac.cn

In recent years, it has been demonstrated experimentally that strong terahertz (THz) radiation can be produced from ultraintense laser-plasma interactions (see [1] and references therein), enabling a high-peak-power THz source for the study of extreme THz wave-matter interactions.[2] The THz radiation itself can also serve as an *in-situ* noninvasive diagnostic for laser plasmas.[3]

The physical mechanisms underpinning the THz generation at different laser-plasma parameters are studied, and it is found that, the THz radiation emitted from the rear side of a laser-irradiated foil is mainly attributed to two processes: transition radiation by fast electrons crossing the target-vacuum boundary, sheath radiation associated with the target normal sheath acceleration of ions. Analytical models are proposed to establish the relationship of THz properties with the laser-plasma characteristic quantities.

Single-shot distortionless characterization of THz properties is key to the THz diagnosis of laser plasmas. Several techniques on single-shot ultrabroadband THz waveform and spectrum detection are developed, based upon the spatially-encoded electro-optic sampling and autocorrelation methods.

With the THz generation models proposed and the THz measurement systems developed, the THz radiation is used to diagnose some laser-plasma characteristic quantities, like the fast-electron temporal duration and the target-rear sheath dynamics at different laser and target parameters. Other applications of THz radiation in the plasma diagnosis will also be reviewed and prospected.

References

[1] G.-Q Liao and Y.-T. Li, IEEE Trans. Plasma Sci. **47**, 3002 (2019).
[2] G.-Q. Liao *et al.*, Proc. Natl. Acad. Sci. U.S.A. **116**, 3994 (2019).
[3] G.-Q. Liao *et al.*, Phys. Rev. X **10**, 031062 (2020).

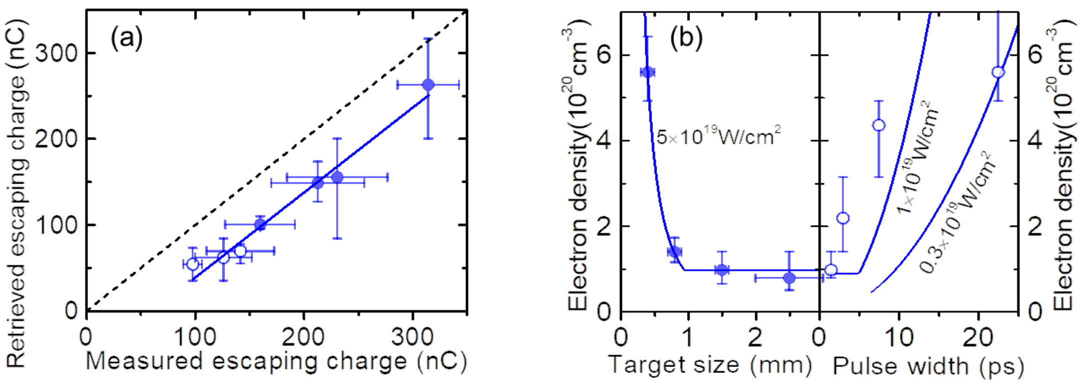

Figure 1. Retrieval of fast-electron characteristic quantities from the measured THz spectra. (a) Retrieved fast-electron bunch charge as a function of the experimentally measured values. The solid line shows the linear fit to the data. (b) Retrieved sheath electron density as a function of the target size and laser pulse duration. Curves represent theoretical evaluations at the indicated laser intensities.