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A dielectric THz-driven Acceleration setup using a metallic waveguide: Simulations and experiment.

It would be hard to picture our world without all the benefits particle accelerators provide humanity. Science, industry, and the medical community extensively utilize accelerators for their applications. As the demand for more powerful accelerators increased in the last decades, their size and cost also increased considerably. The particle accelerator scientific community is looking for more affordable, efficient accelerators that could help break the size and limited injected power of nowadays accelerators. Dielectric Laser-driven Accelerators (DLA) are potential candidates for overcoming the issues above. While using optical lasers instead of radiofrequency waves reduces the size of the accelerating structure and offers more significant accelerating gradients, it comes with some challenges in practice. Thanks to the advance of terahertz lasers in the last decades, employing THz pulses instead of IR frequencies helps to overcome some of the issues faced by structure-based optical laser accelerators. The tenfold to hundredfold increase in the operational wavelength softens the restrictions on the bunch parameters, and the accelerator performance is less prone to decrease due to fabrication imperfections.

This work presents a simple setup for electron acceleration combining a multi-cycle terahertz pulse, a metallic waveguide, and a grating Dielectric THz-driven Accelerator (DTA). The multi-cycle terahertz pulse has been generated by quasi-phase-matching in periodically-poled Lithium Niobate (ppLN). It consists of 12 layers alternating their optical axis in an up-down periodic fashion. A 6-cycle terahertz pulse is obtained from optically pumping the crystal. The power accepted by the accelerating structure is a key figure of merit of any accelerator. Therefore, the waveguide structural parameters have been optimized through simulations to maximize the electric field intended for acceleration. The exiting THz electric field after the waveguide was measured with different foci inside the waveguide with reflective EOS technique. Once the waveguide coupling efficiency has been optimized for this setup, investigation and optimization of dual-grating geometry accelerator parameters are followed. Electron acceleration with the above setup was shown in simulations. The structure performance could be further improved using high-intensity terahertz generation techniques.

Primary author: LEIVA GENRE, Andrés

Co-authors: NASI, Luis (University of Pécs); Mr KISS, Mátyás (University of Pécs); Dr TIBAI, Zoltán (University of Pécs); Prof. ALMÁSI, Gábor (HUN-RUN-PTE High Field Terahertz Research Group); HEBLING, János (Physics Institute, University of Pécs); TURNÁR, Szabolcs (University of Pécs)

Presenter: LEIVA GENRE, Andrés

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