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Effect of driver charge on wakefield characteristics in a plasma accelerator probed by femtosecond shadowgraphy

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Recent experiments have shown the capability of Laser wakefield accelerated (LWFA) electron beams to be suitable driver beams for a particle driven wakefield acceleration (PWFA) stage. The high peak current and short duration of such beams open up the possibility of operating the PWFA stage at density ranges in the order of 10^{18} cm^{-3} . Here, femtosecond optical probing of the acceleration process can be used for the insight view into the plasma wave dynamics during the propagation of the driver. We report the results of this investigation, showing pronounced differences in the morphology of beam driven plasma waves when surrounded by either neutral gas or a broad pre-generated plasma channel. Furthermore an elongation of the first cavity is measured, which becomes stronger with increasing driver beam charge. This observation is supported by 3D particle-in-cell simulations performed with PIconGPU. This work can be extended for the investigation of driver depletion by probing at different propagation distances inside the plasma, which is essential for the development of high energy efficiency PWFAs.

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