On high-quality electron beam generated by breaking wake wave in near-critical density plasmas

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High quality and stable sub-relativistic electron sources are of great demand for various applications in industry and material science [1, 2]. The electron sources in such regime have been previously produced by downscaling a laser-wakefield accelerator or using high-repetition rate laser-plasma accelerators [3, 4, 5].

Here we present a novel method based on the breaking of non-linear Langmuir waves driven by a short intense laser pulse in the near-critical density plasmas. We observe a formation of a thin layer of electrons that are expelled from the target at the plasma-vacuum interface. High quality of the electron bunch is provided using a steep density profile on the target rear side and properly timed breaking of the wake wave. The electron beam is quasi-monoenergetic with several MeV energy range and its divergence depends on the curvature of the plasma wave.

Properties of the electron beam (divergence, energy distribution, number of electrons) can be controlled by adjusting the shape of the target density distribution and the parameters of the laser pulse driver. We demonstrate this effect numerically using multi-dimensional large-scale particle-in-cell simulations and provide analytical formulas that describe the properties of the electron bunch.

References

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