Optimization of wakefield amplitude in the AWAKE experiment

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AWAKE is a proton-driven plasma wakefield experiment [1] under way at CERN that intends to prove one of the concepts for a plasma-based accelerator. The long length of the proton bunches used in the experiment (∼6-12 cm) causes the bunch to undergo a self-modulation process [2], through which the initial bunch is self-consistently transformed into a train of microbunches with lengths of the order of the plasma wavelength. This train can resonantly excite a wakefield in the plasma, and the objective of the experiment is to ultimately accelerate an externally injected electron bunch in this wakefield.

Though plasma-based accelerator concepts promise acceleration gradients a few orders of magnitude larger than with conventional technology, in the case of AWAKE numerical simulations indicate that the amplitude of the wakefield tends to drop significantly after saturation of the self-modulation process, thus undermining the potential energy gain for injected electrons. This work will investigate the causes of this decline using both particle-in-cell simulations and linear wakefield theory. Two possible measures to sustain a high wakefield amplitude after saturation are also studied: the use of an anti-proton driver, since electrons have been known to drive wakefields more effectively than their positively-charged counterparts [3], and the introduction of a plasma density step [4]. Simulation results will be presented.

References

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