

DPP08-2008-000617

Abstract for an Invited Paper
for the DPP08 Meeting of
the American Physical Society

Beam loading in the nonlinear regime of plasma-based acceleration¹

MICHAEL TZOUFRAS, UCLA

An analytical theory for the interaction of a negatively charged bunch with a nonlinear plasma wave is developed to make it possible to design efficient laser- and/or beam-driven accelerators that generate truly monoenergetic electron beams. This theory allows us to choose the charge, the shape and the placing of the beam so that the efficiency is maximized and the beam quality optimized. For intense drivers the nonlinear wake is described by the trajectory of the blowout radius and beam loading arises when the radial space-charge force of the beam acts back on the trajectory. Starting from the nonlinear theory by W. Lu et al. [1], an equation for the wakefield in the presence of an electron bunch is derived. The shape of the ion channel in an unloaded wake is determined and the modification of the wake due to the presence of flat-top electron bunches is studied. It is shown that the energy spread of an externally injected flat-top (or Gaussian) electron bunch can be kept low by choosing the correct charge per unit length and the analytical results are confirmed with PIC simulations. The bunch profile that leads to zero energy spread is found to be trapezoidal. The conversion efficiency from the fields of the bubble to the accelerating electrons is determined, and it is shown that for optimal bunches it approaches 100%. The differences between nonlinear and linear [2] theory are described and the advantages of operating in the nonlinear regime are discussed. [1] W. Lu et al., Phys. Rev. Lett. **96**, 165002 (2006); Phys. Plasmas **13**, 056709 (2006). [2] T. Katsouleas et al., Particle Accelerators, 1987, **22**, pp. 81-99.

¹Work supported by the Department of Energy under grants DE-FG02-03ER54721, DE-FG03-92ER40727, DE-FG52-06NA26195, and DE-FC02-07ER41500. Simulations were carried out on the DAWSON Cluster funded under an NSF grant, NSF-Phy-0321345, and at NERSC.