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Controlled electron injection in laser wakefield accelerators using axially tailored plasmas[1]

ANTHONY GONSALVES, Lawrence Berkeley National Laboratory

Controlling injection of electrons in laser plasma accelerators (LPA's) is crucial for improving the beam quality and enabling applications such as free electron lasers (FEL's). In addition, techniques are needed to control the amount of charge, energy and energy spread. To date, LPA's have typically operated in a highly nonlinear regime in which electrons are self-injected into a laser-excited plasma density wave. Although percent level energy spread beams have been demonstrated experimentally [1-4], production of lower energy spread beams will require accurate control of the injection process. In order to avoid self-trapping, an LPA would have to operate with lower wake amplitude, whether linear or non-linear. This also necessitates the use of a laser guiding structure to overcome diffraction of the laser beam. Such guiding structures have been obtained by transversely shaping the plasma density profile and they have successfully been used in experiments using laser-produced [2] or capillary-based channels [4]. In this talk, experimental results are presented that demonstrate the use of a longitudinally tailored plasma density profile in a capillary discharge waveguide to control trapping, significantly improving LPA performance. A gas jet was embedded in the capillary to locally alter the plasma density. It was found that electrons can be trapped and accelerated to hundreds of MeV using plasma densities in the capillary lower than in previous experiments, where no stable self-trapped electron beams were obtained in previous experiments [5]. It is found that using a longitudinally tailored density profile improves and increases control over electron beam properties.

[1] Mangles et al., Nature 431, 535 (2004)
[2] Geddes et al., Nature 431, 538 (2004)
[3] Faure et al., Nature 431, 541 (2004)
[4] Leemans et al., Nat. Phys. 2, 696 (2006)
[5] Nakamura et al., Phys. Plasmas 14, 056708 (2007)

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