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Laser Assisted Ionization Injection for Plasma Wakefield Accelerators: A Plasma Cathode WEI LU, THU/ UCLA, A. DAVIDSION, W. AN, P.C. YU, CHAN JOSHI, WARREN MORI, UCLA, F. LI, X.L. XU, C.J. ZHANG, J.F. HUA, THU — In PWFA, controlled injection of high quality electron into the wakefield is of utmost importance. In this talk, a method based on laser ionization injection in a plasma wakefield accelerator is proposed and tested through 2D/3D PIC simulations. In this scheme,an ultrashort high current electron beam ($I_p > 7kA$) is used to drive a nonlinear wake in a preionized or self-ionized plasma, then a short laser pulse (with focused intensity I $10^{14}W/cm^2$) synchronized to the electron beam driver ionizes a second gas with higher ionization potential (e.g.,Helium) to produce controlled injection when the time delay between the electron driver and the trailing laser is appropriate. The key advantage of this scheme is that the intrinsic normalized emmitance of the generated electron beam could be as small as 0.01 mm mrad due to the very small transverse beam size (micron) and very small initial transverse momentum (0.01mc). We will show through 3D PIC simulations that such small emittance is achievable under certain conditions. It is also found that the emitance at high beam current strongly depends on the space charge effect of the generated bunches although the acceleration gradient is thousands times greater than that of the RF photocathode. Methods for optimizing the beam brightness and the overall efficiency will also be discussed.

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