

Two-Pulse Ionization Injection into Quasi-Linear Plasma Wakefields

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To produce high quality electron beam from laser wakefield accelerators requires control of injection and trapping of electrons by the plasma wakefield. Several techniques for controlling injection have been proposed and demonstrated, but none has been shown to control injection into linear or quasi-linear wake-fields.

We describe a scheme in which electrons ionized from a dopant by an “injection” laser pulse are trapped into the quasi-linear wakefield driven by a collinear “drive” pulse. The Rayleigh range of the injection pulse is chosen to be short, ensuring that the injection is localized; this can be achieved by using a small laser spot size or simultaneous space time focusing. This approach offers several advantages: electrons are injected close to the axis, with low transverse momentum and emittance; localized injection results in low relative energy spread; and the charge of the injected bunch may be controlled by varying the spot size of the injection pulse, or by adjusting the density of the dopant species.

We analyze this scheme using 1D fluid, and 2D particle-in-cell simulations and use these to demonstrate controlled generation of electron beams with low transverse emittance and relative energy spreads of a few percent.

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