Self-injection of multiple electron microbunches into a beam-driven plasma bubble

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The self-injection of electrons into non-linear plasma wave is governed by the rate of change of its phase velocity. In uniform plasma the phase velocity is difficult to control in the case of laser-driven plasma wakefields, where the spatial and spectral evolution of the laser pulse causes small fluctuations in the size of the cavity [1, 2]. The expansion of the bubble can be triggered by using a non-uniform plasma with sharp density transition [3] or with continuously decreasing density [4]. In our work we study an extreme version of the scheme presented in Ref. [4], where continuous injection was observed. In our case higher beam charges and longer density down-ramps are considered leading to bunched injection of electrons. As an example, Fig. 1 shows the injected micro-bunches near the end of the density ramp.

The plasma density profile in our simulations is described by the following function:

$$n_e = n_0 \left[\rho + (1-\rho)\frac{1+\cos(\pi x/L_n)}{2} \right], \qquad (1)$$

where $\rho = n_1/n_0 < 1$, with n_0 and n_1 being the density before and after the ramp, respectively, and x goes from 0 to L_n. Although the density profile is smooth the injection is not continuous. The reasons of this will be discussed in the presentation and a semi-analytical model will be presented, which gives an estimation for the periodicity and size of the injected bunches.

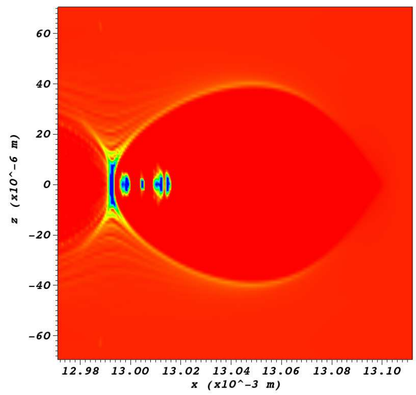

Figure 1: *Density distribution of electrons from a simulation where the driving beam charge is 2.4 nC and the density down-ramp is $L_n = 1.5$ cm long.*

References

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