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Optimization of single bunch driven plasma wakefield acceleration in quasi-nonlinear regime

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We report our studies on the single bunch driven plasma wakefield acceleration (PWFA) in quasi-nonlinear regime (QNL). For the QNL, a weak blowout can be obtained by using a relatively low-charge driving bunch with a density larger than that of the background plasma. In this case, the bubble formation leads to ultra-high accelerating wakefield and a transformer ratio exceeding the linear limit of 2, while the low total driving charge preserves certain linear behaviors of the excited wakefield. It was demonstrated that a cigar bunch shape was suitable for producing the so called QNL-PWFA regime. The case studies showed how one could optimize the plasma density for given driving bunch parameters and how to improve the bunch shape in order to make the useful accelerating wakefield and the transformer ratio as large as possible, under the guidance of the conventional linear theory. A useful accelerating field gradient of 3.7 GV/m and a transformer ratio of 2.3 were obtained via the interaction of a 100 μm, 250 pC relativistic electron bunch with the underdense ambient plasma.

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