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# Energy conserving theory of plasma blowout

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We present an energy-conserving theory of plasma wakefield in the strongly-nonlinear ("bubble"or "blowout" ) regime. Previous phenomenological models [W. Lu et al. PRL 96, 165002 (2006)] were based on using the electron motion equations in plasma and assumptions about the electron sheath on the bubble's boundary. However, they often included fitting parameters and, in general, provided an unsatisfactory fit to results of particle-in-cell (PIC) simulations in the case of smaller size bubbles. In the new theory, we derive a different equation for the boundary of the bubble starting from the energy conservation law in a plasma wakefield. The derived equation does not contain fitting parameters and accurately describes the boundary of the bubble and the accelerating field in it in a wide range of driver parameters, including the case of small transverse sizes of the bubble. We develop a way to self-consistently describe the excitation of the bubble by an electron driver based on the new theory. We also show that the new model gives similar results as the previous models in the limit of a large bubble size. The predictions of the new model are verified by 3D PIC simulations and show very good correspondence to them.

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