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Numerical investigation on the formation and stability of a hollow electron beam in the presence of a plasma wake field driven by an ultra-short electron bunch

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A numerical investigation on the spatiotemporal evolution of an electron beam, externally injected in a plasma in the presence of a plasma wake field is carried out. The latter is driven by an ultra-short relativistic axially-symmetric femtosecond electron bunch. We first derive a novel Poisson-like equation for the wake potential where the driving term is the ultra-short bunch density, taking suitably into account the interplay between the sharpness and high energy of the bunch. Then, we show that a channel is formed longitudinally, through the externally injected beam while experiencing the effects of both the beam-plasma self-interaction and the bunch-driven PWF, within the context of thermal wave model. The formation of the channel seems to be a final stage of the 3D evolution of the beam. This involves the appearance of small filaments and bubbles around the longitudinal axis. The bubbles coalesce forming a relatively stable axially-symmetric hollow beam structure.

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