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Analytical and computational study of nonlinear collisionless filamentation of a relativistic electron beam in plasma VLADIMIR KHUDIK, GENNADY SHVETS, The University of Texas at Austin, IGOR KAGANOVICH, Princeton Plasma Physics Laboratory — The nonlinear stage of Weibel instability of a relativistic beam propagating through ambient plasma is studied analytically and through computationally efficient hybrid simulations. In our hybrid approach [1], beam electrons are modeled using numerical macroparticles while plasma electrons are modeled as a passive fluid instantaneously responding to the beam evolution. But in contrast to [1], present numerical analysis captures the effects of violation of the charge quasi-neutrality near the boundaries of high-current filaments. Assuming for analytical tractability that the beam density is small, we find the self-similarity law for nonlinear dynamics of the Weibel instability. It is found that the electron energy distribution of the beam particles trapped in the filaments is close to Maxwellian. Using the Boltzmann distribution of the electron density in transverse plane, we derive a closed equation describing filament structure. This analytical model of fully thermalized filament allows us to evaluate the fraction of initial beam energy transferred to transverse particle beam motion, to plasma electron motion, and to the magnetic field. The analytical results are compared with those from hybrid simulations. [1] Oleg Polomarov et al., Phys. Plasmas 14,043103 (2007).
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