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Three-dimensional kinetic analysis of longitudinal space-charge waves in a relativistic electron beam AGOSTINO MARINELLI, ERIK HEMSING, JAMES ROSENZWEIG, UCLA — We develop a three-dimensional analysis of longitudinal space-charge waves in a relativistic electron beam. Our analysis includes the effects of longitudinal thermal motion due to energy spread and emittance, transverse betatron oscillations and edge effects due to the finite transverse size of the beam. We reduce the system of coupled Vlasov/Maxwell equations to an integro-differential eigenvalue equation which represents the three-dimensional dispersion relation for the plasma oscillation eigenmodes. The dispersion relation can be expressed in terms of four dimensionless scaling parameters. We solve the dispersion relation by means of an approximate variational method as well as a numerical discretization method and use the universally scaled solutions to explain the main physical features of the problem. Finally, the initial value problem is solved by means of a bi-orthogonal mode expansion of an arbitrary initial perturbation in six-dimensional phase space and used to describe space-charge induced amplification and suppression of beam microbunching. Possible experimental applications of this analysis in the context of free-electron laser injectors are also discussed.

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