CHAOTIC PARTICLE TRAJECTORIES IN HIGH-INTENTSITY FINITE-LENGTH CHARGE BUNCHES*

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A Vlasov-Maxwell equilibrium for a charged particle bunch is given by the distribution function that is a function of the single-particle Hamiltonian $f = f(H)$, where in an axisymmetric cylinder $H = \mathbf{p}^2/2m + \kappa_\perp r^2/2 + \kappa_z z^2/2 + q\phi(r,z)$, the kinetic energy is $\mathbf{p}^2/2m$, $\kappa_\perp$ and κ_z are the external focussing coefficients in the transverse and longitudinal directions, and ϕ is the self-field potential determined self-consistently from Poisson's equation

$$\nabla^2\phi = -4\pi q \int d^3p f(H). \qquad (1)$$

The self-field potential ϕ introduces a coupling between the otherwise independent r and z motions. Under quite general conditions, this leads to chaotic motion. Poisson's equation is solved using a spectral method in z and a finite-difference method in r, and a Picard iteration method is used to determine ϕ self-consistently. For the thermal equilibrium distribution $f = A\exp(-H/T)$, the single-particle trajectories display chaotic behavior. The properties of the chaotic trajectories are characterized.

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