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Emittance Growth in Space-Charge Dominated Beams Due to the Thermalization of Collective Mode Perturbations

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Abstract (Original)

Real beams are expected to have some degree of space-charge nonuniformity and rms envelope mismatch in any accelerator system. For intense beams, such perturbations will evolve and can become thermalized as the distribution relaxes to a more thermal-like distribution characterized by uniform density and temperature. Past studies [1] have employed a continuous focusing model and energy conservation to estimate emittance increases from the thermalization of initial rms mismatches in the beam envelope and initial space-charge nonuniformities. Here we extend these studies to analyze the emittance growth of an initial beam composed of a space-charge dominated beam equilibrium with an azimuthally symmetric normal mode perturbation. These normal modes were derived in an earlier study using a fluid theory [2] and are expected to be characteristic of beams with flat density profiles -- a general feature of smooth equilibrium distributions in a space-charge dominated regime. The initially perturbed beam is taken to have the nonuniform space-charge profile and self-consistent envelope mismatch characteristic of a single normal mode perturbation. Since an arbitrarily perturbed beam will evolve as a superposition of normal modes, this formulation helps characterize possible emittance increases associated with classes of nonuniformities in a self-consistent manner.


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