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Quasi-linear theory of single-pass microbunching instability

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The existing theoretical treatment of single-pass microbunching instability (MBI) typically assumes a coasting beam and adopts a linear framework, within which the microbunching gain may grow without bound. While the inclusion of intrabeam scattering (IBS) introduces damping effects that may suppress excessive gain, these models remain fundamentally linear and do not capture saturation behavior. In this work, we develop a quasi-linear theory of MBI based on the Vlasov equation, incorporating the evolution of beam energy spread induced by the instability itself. The quasi-linear formulation yields a set of coupled equations describing the evolution of the bunching factor and energy spread, still under the coasting beam approximation where different modulation wavelengths evolve independently. This approach provides a more realistic description of the nonlinear evolution of MBI and offers insight into its natural saturation mechanism.

Footnotes

Funding Agency

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