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Bunched-beam theory of microbunching instability

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Conventional theory of single-pass microbunching instability (MBI) is primarily based on the coasting-beam approximation, which assumes that the modulation wavelength is much shorter than the bunch length. However, in isochronous beamlines, the characteristic modulation wavelength may sometimes become comparable to the bunch length, rendering the coasting-beam assumption invalid. In this paper we develop a bunched-beam theory of MBI, starting from the linearized Vlasov equation, aiming to quantify the impact of finite bunch length on the evolution of density modulations. Our analysis reveals that the final MBI gain, or the amplified bunching factor, exhibits a dependence on the initial modulation phase, a feature absent in the existing coasting-beam model. The proposed bunched-beam formulation may offer additional physical insights into the underlying mechanism of MBI, particularly in regimes where the finite extent of the bunch plays a non-negligible role.

Footnotes

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