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Fast models for collective effects in linear accelerators

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The applications envisioned for advanced linear accelerator-based facilities rely on the production of intense particle beams delivered at high repetition rates. Indeed, the demanding brightness and luminosity foreseen by electron driven radiation sources and linear colliders, respectively, imply the coexistence of high peak currents and small transverse emittances. The acceleration of such beams in high gradient machines exposes charged particles to a mutual parasitic interaction which is caused by the excitation of wakefields acting either within the same bunch or among different bunches. Moreover, electron beams produced by rf-photoinjectors enter the main linac with energies in the 4-6 MeV range which implies a non-negligible sensitivity to space-charge effects. The presence of the aforementioned self-induced fields may dilute the phase space quality and, thus, their effect has to be investigated carefully in order to ensure the design performance. Beam dynamics studies including collective effects typically require significant numerical resources and, therefore, we present here reliable methods to describe such processes by means of quasi-analytical approaches that simplify the computation. Such models are embedded in a custom tracking code that provides a fast simulation tool for the dynamics of electron linacs in presence of space charge forces and wakefield effects.

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