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Simulating relativistic beam-plasma instabilities with the quasistatic PIC code QuaSSis

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Quasistatic particle-in-cell (QSPIC) codes[1] are increasingly used to study laser or plasma wakefield accelerators. QSPIC codes decouple the slow evolution of a beam from the fast response of a plasma, which reduces the computational cost by several orders of magnitude compared with conventional PIC codes. In this presentation, we demonstrate the potential of the QSPIC method to investigate relativistic beam-plasma instabilities[2].

QuaSSis, a new QSPIC code, is first employed to simulate the oblique two-stream instability (OTSI) arising during the propagation of µm-scale, 10 GeV electron beams through a collisionless plasma. Its predictions are validated against the PIC code CALDER[3]. We then describe a new numerical scheme adapted to periodic transverse boundary conditions, which simulates transversely infinite beams, the results of which can be compared with an analytical spatiotemporal model for the OTSI[4]. Finally, we discuss how the initial noise, intrinsic to the PIC method can be controlled in QSPIC simulations to ensure reliable predictions of instability growth rates and saturation levels.

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[2]A. Bret et al, Phys. Plasmas 17, 120501 (2010).
[3]E. Lefebvre et al., Nucl. Fusion 43, 629 (2003).
[4]P. San Miguel Claveria et al., Phys. Rev. Res. 4, 023085 (2022).

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