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Plasma modeling of beam-electron cloud instabilities in circular accelerators

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A 3D Particle-In-Cell model for continuous modeling of beam and electron cloud interaction in a circular accelerator is presented. A simple model for lattice structure, mainly the Quadruple and dipole magnets and chromaticity have been added to a plasma PIC code, QuickPIC, used extensively to model plasma wakefield acceleration concept. The code utilizes parallel processing techniques with domain decomposition in both longitudinal and transverse domains to overcome the massive computational costs of continuously modeling the beam-cloud interaction. Through parallel modeling, we have been able to simulate long-term beam propagation in the presence of electron cloud in many existing and future circular machines around the world. The exact dipole lattice structure has been added to the code and the simulation results for CERN-SPS and LHC with the new lattice structure have been studied. The code is also used to model electron cloud effects in PEP-II storage ring at SLAC. The pipe geometry in this ring is much bigger than the beam cross section that the boundary conditions turned out to be inconsequential on beam dynamics, therefore smaller pipe cross section is used in the modeling to reduce the computational costs. Also the simulation results are compared to the results from the two macro-particle modeling for strong head-tail instability. It is shown that the simple two macro-particle model can capture some of the physics involved in the beam-electron cloud interaction qualitatively.