Elliptical corrections to the gyroaveraging operation in gyrokinetic Particle-in-Cells in high E-field-gradients regions

Xin Zhi Tan(1), Davide Curreli(1), Robert Hager(2), Seung-Hoe Ku(2), and C.S. Chang(2)

(1) University of Illinois at Urbana Champaign
(2) Princeton Plasma Physics Laboratory

In gyrokinetic Particle-in-Cell codes, a particle is treated as a charged “ring” driven by a force from the effective potential representing the averaged potential over the ring. Thanks to gyroaveraging, a particle’s charge is split into N portions and projected onto a circular gyro-ring of size equal to one Larmor radius at equidistant gyro angles. However, in a region with large electric field gradients, like the edge pedestal, the particle orbit departs from being circular, deformed by the presence of the electric field and electric field shear. At those locations, the use of circular rings is no longer a valid assumption, and higher-order corrections must be applied. In this work, we solve the Newton-Lorentz equation for a single particle in the presence of a uniform magnetic field and a linear gradient electric field at an arbitrary angle. It is shown that the existence of an electric field gradient will modify the gyrofrequency of the particle and deform the circular gyromotion to an elliptical one. Based on the result obtained, an explicit analytical expression for first-order elliptical corrections to the gyroaveraging operation is derived. Future work includes the implementation of the correction factor obtained in XGC.