Neural network assisted electrostatic global gyrokinetic toroidal code using cylindrical coordinates

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Several gyrokinetic simulation codes, such as GTC, GYRO, ORB5, GENE, etc., have been developed to understand the microturbulence in the linear and nonlinear regime of the tokamak and stellarator core. These codes use flux coordinates to reduce computational complexities introduced by the anisotropy due to the presence of confinement magnetic fields. But flux coordinates encounter mathematical singularity of the metric on the magnetic separatrix surface. To overcome this constraints, we have developed a neural network-assisted global toroidal PIC code (GTC-X [1]) in cylindrical coordinates to study the electrostatic microturbulence in realistic tokamak geometries. In particular, GTC-X uses a cylindrical coordinate system for particle dynamics, which allows particle motion in arbitrarily shaped flux surfaces, including the magnetic separatrix of the tokamak. We use an efficient particle locating hybrid scheme, which use a neural network and iterative local search algorithm, for the charge deposition and field scattering . GTC-X uses the field lines estimated by numerical integration to train the neural network in universal function approximator mode to speed up the subroutines related to gathering and scattering operations of self-consistent gyrokinetic simulation. Currently GTC-X is the only code which integrates the multilayer neural network with field line geometry for self-consistent simulation in the world fusion program. Finally, as further verification of the capability of the new code, we present results from self-consistent simulations of ion temperature gradient modes in the core region of tokamak.

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References

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