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Gyrokinetic Modeling with an Extended Magnetic Equilibrium including the Edge Region of Large Helical Device

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We investigate radial electric field structure in Large Helical Device and its impact on high-energy particle loss at the material wall. We employ global gyrokinetic particle-in-cell code for whole-device simulation, X-point Gyrokinetic Code (XGC), which is currently being extended to non-axisymmetric geometries. The whole-device modeling of fusion plasma is needed to understand edge plasma phenomena strongly coupled to neoclassical and turbulent physics in the core region such as H-mode transition, divertor heat load, X-point particle loss and so on.

As the first step, we have demonstrated two typical processes in LHD within the same framework of XGC : (i) GAM oscillation and its damping in a density profile or an electric field perturbation and (ii) long-time motion of high-energy particles and particle loss at the material wall. Our results are in agreement with previous simulation studies using separate codes. One is transport simulation limited in the core region and the other is particle tracing simulation without electric field perturbation. We have also investigated particle loss under the effects of ambipolar radial electric field, which is observed after GAM oscillation. The electric field affects the particle loss in two different ways in accordance with the particle energy: (i) confinement due to the inward electric field for high energy range and (ii) additional particle loss due to the disturbance of particle orbit for intermediate energy range. The electric field also affects the strike point of high-energy particle in divertors.

The present scheme including (i) combined use of cylindrical and field-aligned triangle meshes and (ii) extension of VMEC equilibrium using a virtual casing method, would be promising for whole device gyrokinetic modeling of Stellarators without artificial boundary at the last closed flux surface.

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