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# A development of full-f gyrokinetic code for whole device modeling

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The properties of the edge and scrape-off-layer (SOL) plasma in tokamaks determine the overall performance of the tokamak. Therefore, an understanding of the physics of plasma in edge and SOL regions is key to improve the efficiency of tokamak fusion reactor. However, due to the complications of edge and SOL, numerical simulations are necessary to understand theoretically in the boundary plasma, gyrokinetic simulation on the domain of tokamak whole device modeling including the edge and SOL regions can be important.

Discontinuous Galerkin (DG) methods are a class of finite element methods using element-wise discontinuous basis functions in order to represent a solution in the approximation space. DG methods have good features of both a finite element method and a finite volume method. Since the basis functions of DG methods can be discontinuous across element interfaces and have nonzero values for only one element, DG methods have the advantages which are absent in traditional continuous finite element methods, such as highly local data structure, high parallel efficiency, ability to handle complex geometry.

In this work, we present the development of a new full-f gyrokinetic code based on DG method. The new code can solve a gyrokinetic model for toroidally symmetric plasma. The exponentially weighted polynomials are employed to approximate the gyrokinetic distribution function[1]. An unstructured triangular mesh is generated for the feasibility of simulations on realistic tokamak geometry, and a rectangular mesh is added for velocity space. The Parallel Unstructured Mesh Infrastructure (PUMI) library is used to parallelize the distributed meshes. Runge-Kutta methods are applied for time discretization and numerical fluxes are used to approximate the fluxes.

We applied the standard continuous Galerkin method using Bell triangle for gyrokinetic Poisson equation. Bell triangle (also called reduced quintic element) is a $C^1$ element consists of quintic polynomial basis functions with 18 degrees of freedom[3]. The basis functions of Bell triangle satisfy $C^1$ continuity, that is, their derivatives are continuous across element interface while basis functions of $C^0$ elements (such as Lagrange and Hermite elements) have discontinuous derivatives on edges. The gyrokinetic field solver provides the globally continuous electric field, which can be obtained using the gradient of electric potentials. However, the standard affine transformations which map a reference element to each physical element do not preserve the function space of Bell triangle, so a general approach[3] is considered.

We present benchmark simulation results on a circular geometry with an up-down symmetric boundary.

References

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