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Development of the Gyrokinetic-MHD Hybrid Code GMEC

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We report the status of the Gyrokinetic-MHD Hybrid Code GMEC being developed for simulations of energetic particle (EP)-driven Alfven instabilities and EP transport in magnetic fusion plasmas such as ITER. In the hybrid model, electrons are treated as a fluid, EPs and thermal ions are described by gyro-kinetic equations. The energetic particle effects enter in the gyrokinetic vorticity equation via the pressure term which is obtained by solving the gyrokinetic equations using PIC method. The field-aligned coordinates and meshes are used to efficiently resolve mode structures of high-n Alfven modes. Five-points 4th order finite differences and 4th order Runge-Kutta method are used for numerical differentiations and time advances respectively.

The Compile-time Symbolic Solver (CSS) is developed to generate coding from vector equations directly [1]. CSS is a C++20 template metaprogramming code. It expands vector equations into components scalar equations at compile-time, and greatly simplifies coding of differential equations in toroidal curvilinear coordinates. Both MPI and TBB are used for parallelization. Up to now, a simplified version of GMEC has been completed with initial verifications for ideal ballooning modes and EP-driven TAEs. The alpha particle-driven Alfven eigenmodes in CFETR have also been simulated successfully. Details of GMEC and its applications will be presented.

References

[1] P. Y. Jiang et al., “Compile-time Symbolic Solver for the Gyrokinetic-MHD Hybrid Code GMEC”, this meeting.