Non-uniform meshes in Gyrokinetic Simulations

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Steep gradients at the edge of the plasma lead to features which are difficult to resolve. The current 5D grids (3 spatial coordinates, 2 velocity coordinates) used by gyrokinetic codes such as GYSELA[1] already represent more than 100 billion points, so increasing the refinement uniformly to handle this problem would be too costly. One solution to this problem is non-uniform points.

In this talk we discuss the changes that need to be made to the GYSELA code to accomodate non-uniform meshes and the trade-offs involved in such a choice. Bearing in mind that the GYSELA code is a code with more than 50 000 lines, based on a hybrid MPI/OpenMP parallelisation, and optimised for more than 100 000 cores, in-depth studies are presented in models with reduced dimensionality.

A Vlasov-Poisson 1D-1V model, used for studies of the plasma sheath is used to investigate the semi-Lagrangian method based on non-uniform splines. The sheath is a section of the plasma, which presents numerically troublesome, steep gradients. This VOICE code (which is a mini version of GYSELA) has been modified and optimised on a GPU to operate on a non-uniform mesh. These improvements allowed simulations to be carried out which were previously unattainable, and validate the semi-Lagrangian method on non-uniform splines.

Manufactured 2D problems, are used to investigate three possible solvers for the quasi-neutrality equation. These solvers are: (i) a 2D finite elements solver based on splines [2] developed in the SELALIB library [3], (ii) a solver based on the AMReX library[4] which uses finite volumes on a uniform cartesian mesh with embedded boundaries, and (iii) a solver developed by the CERFACS which uses finite differences on a logical mesh[5].

References

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