The flux coordinates independent (FCI) approach to plasma turbulence simulations

M. Ottaviani[1], F. Hariri[1,2], P. Hill[1,3], G. Latu[1], M. Meherenberger[4], Y. Sarazin[1], E. Sonnendrücker[5]

1) CEA, IRFM F-13108 St-Paul-lez-Durance, 2) EPFL, CRPP, CH-1015 Lausanne, Switzerland, 3) University of York, 4) University of Strasbourg, 5) IPP Garching.

In this work, the flux coordinate independent (FCI) approach [1] to plasma turbulence simulations is presented in the general case of arbitrary magnetic fields including stochastic ones and X-point configurations.
The method, initially devised in the context of fluid codes based on finite difference schemes, allows the direct calculation of the parallel derivatives in machine coordinates with a small number of toroidal points, thereby saving a couple of order of magnitudes in computer resources for ITER scale simulations.

Various results on FCI are discussed in this presentation:

1. The validation of the method via comparison with exact results of drift wave and sound wave dynamics in both cylindrical and X-point configurations [2], and with known results of ITG turbulence in cylindrical geometry [3].

2. The application of the FCI-based code FENICIA to the question of the interaction of ITG turbulence with a static magnetic island. The main result of this study is that the critical island size for temperature profile flattening is controlled by turbulence spreading and it is proportional to the turbulence correlation length [4]. This suggests that the threshold (minimal seed island) for NTM growth can be as low as a few Larmor radii, smaller than what would be given by a Fitzpatrick-type calculation based on the effective anomalous conductivity.

3. The extension of the FCI idea to kinetic codes based on the semi-Lagrangian method. In the context of the SELALIB [5] development project, the approach has been tested and validated on the constant oblique advection equation and on a 4D drift kinetic model with oblique magnetic field in cylindrical geometry [6].

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