The Flux-Coordinate Independent Approach for Plasma Turbulence Simulations

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Field-aligned coordinates are necessary to optimize plasma turbulence codes. They are widely employed in today's codes allowing the number of grid points needed to represent structures elongated along the magnetic field to be greatly reduced. In this work, we present the development and implementation of a new approach to the problem of field-aligned coordinates in magnetized plasma turbulence simulations called the FCI approach, standing for Flux-Coordinate Independent.

The method exploits the elongated nature of micro-instability driven turbulence, which typically have perpendicular scales of the order of a few ion gyro-radii, and parallel scales of the order of the machine size. It is based on two concepts. The first is using an arbitrary mesh not based on magnetic flux coordinates; the second is computing the parallel gradient operator by tracing the magnetic field lines from one poloidal plane to the next and interpolating at end points.

The FCI approach, not based on magnetic flux variables, has been introduced and validated in [1]. It was also demonstrated, for the first time, in [3] that FCI can efficiently deal with X-point configurations and O-points such as the magnetic axis. The approach was also formulated to handle 3D magnetic configurations [3].

Employing FCI opens up the way for Plasma turbulence simulations with X-points and enables the study of important physical processes in complex geometries, such as turbulence and magnetohydrodynamical (MHD) instabilities in a tokamak plasma.

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[2] F. Hariri, P. Hill, M. Ottaviani, and Y. Sarazin. The flux-coordinate independent approach applied to X-point geometries. Physics of Plasmas, 21(8):082509, August 2014. ISSN 1070- 664X. doi:10.1063/1.4892405. URL http://scitation.aip.org/ content/aip/journal/pop/21/8/10.1063/1.4892405.

[3] F. Hariri, P. Hill, M. Ottaviani, and Y. Sarazin. Plasma turbulence simulations with X-points using the flux-coordinate independent approach. pages 1-20, September 2014. URL http://arxiv.org/abs/1409.2393. (accepted, to be published in PPCF 2015)