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The Field line map approach to plasma turbulence simulations

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Abstract

The complex geometry in the edge and scrape-off layer poses a challenge to simulations of magnetically confined plasmas. The usually employed field/flux-aligned coordinates become singular on the separatrix/X-point. In the field line map approach these problems are avoided and a separatrix can be treated [1, 2, 3, 4] (see also FCI approach [5, 6, 7]). The approach is based on a cylindrical grid, and the characteristic flute mode property ($k_\parallel \ll k_\perp$) of structures is exploited computationally via grid sparsification in the toroidal direction. A field line following discretisation for parallel operators is then required, which includes field line tracing and interpolation or integration. The drawback of the approach is that there arises a numerical erroneous perpendicular coupling among distinct field lines, which causes numerical diffusion. Based on the support operator method [8] a numerical scheme was constructed for the parallel diffusion operator, which exhibits only very low numerical diffusion. The numerical concept was applied to a simple plasma turbulence model, the Hasegawa-Wakatani equations [9], which were implemented in the new code GRILLIX. Extensive benchmarks show the validity of the field line map approach in general and GRILLIX in particular. Finally, first geometrical effects of the X-point on turbulent structures have been identified.

References

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