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The field line map approach for simulations of plasma edge/SOL turbulence

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The complex geometry in the edge and scrape-off layer poses a challenge to simulations of magnetically confined plasmas, since the usually employed field/flux-aligned coordinates become singular on the separatrix/X-point.
A field line map approach (see also flux-coordinate independent approach) offers a promising solution to these problems. The approach is based on a cylindrical grid, which is Cartesian within poloidal planes, and the characteristic flute mode property (k_parallel « k_perpendicular) 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 and/or discrete integration. Advanced numerical techniques were developed in order to overcome the critical issue of numerical diffusion and the treatment of boundaries. The whole concept is implemented in the code GRILLIX, which features flexibility in treating different and complex geometries, especially with separatrix and X-point(s). Simulations based on a simplified turbulence model (Hasegawa-Wakatani) elucidate the effect of the X-point on turbulent structures. Furthermore, a full-f drift reduced Braginskii model, where the Boussinesq approximation is dropped, is employed for studies on blob propagation in the scrape-off layer.

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