Conformal coordinates for turbulence computations on shaped tokamak geometries

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The magnetised nature of the tokamak plasma yields a strong spatial scale separation between the directions along (parallel) and across (perpendicular) the equilibrium magnetic field. The use of field aligned coordinates is therefore a common practice in turbulence computations due to its numerical efficiency in treating the parallel dynamics. This comes at a price for strongly shaped tokamak magneto-hydro-dynamic (MHD) equilibria, which is typically the situation at the plasma edge region, where special features like an X-point may be present. Namely, a correct representation of the perpendicular dynamics at finite resolution may not be possible unless specific counter-measures are devised to compensate for the inherent rapid variation of the field aligned coordinate systems’ metric coefficients along the field lines, which translates into grid mesh deformation. A novel geometrical treatment has been introduced to address this issue. A consistent combination of magnetic field aligned and conformal coordinates [1] is used together with a shifted metric procedure [2]. This allows an efficient treatment of the dynamics along the magnetic field lines while enforcing the necessary isotropy in the plane perpendicular to it at the grid spacing level, best representing the turbulence physical properties. We present a comparative study between the standard flux tube and the novel conformal geometrical treatments to assess their limits of validity. This is done by means of gyrofluid turbulence computations [3] using both treatments on different MHD equilibria.

References

