Towards an automated mesh generation framework for Tokamaks

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Due to the very large anisotropic character of strongly magnetized plasma, the use of flux aligned grid is generally believed to be highly useful (or even mandatory) to obtain accurate and reliable simulations for fusion applications. For real geometries, the magnetic topology can only be computed by the use of specialized equilibrium solvers (e.g [1]) solving the non-linear Grad-Shafranov equation. The output of these solvers then have to be used as input to construct flux aligned meshes that respect the magnetic topology. This process usually require some manual input and expertise from the final users to identify the relevant features of the magnetic topology (X points, magnetic axis).

Here, we will describe an original method for the automated construction of flux aligned grids. This method assumes that the magnetic flux is a Morse function [2] and consequently that the results of Morse theory can be applied : the topological set of the iso-contours of the flux function consists of finite connected components that are either

1. Circle cells which are homeomorphic to open disks,
2. Circle bands which are homeomorphic to open annulus,
3. Saddle connections.

The construction of flux aligned grid relies then on the analysis of the singularities of the magnetic flux function and the construction of a graph known as the Reeb graph [3] that encodes the segmentation of the physical domain into sub-domains that can be mapped to a reference square domain. We will present several examples taken from existing tokamaks to illustrate this grid generation process.

This talk will be followed by the talks of J. Lakhlili and H. Speleers where we will detail the construction of the sub-domains and the global domain while ensuring a given regularity between the sub-domains.

References

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