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Simulating Edge Transport in MAST-U Using the FELTOR Code

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We investigate particle transport in the edge region of the MAST Upgrade (MAST-U) spherical tokamak prior to the L-H transition using the Full-F Electromagnetic code in TORoidal geometry (FELTOR) [1]. Three-dimensional simulations are performed using experimental input from discharge #48004 [2], which is part of a dedicated campaign exploring H-mode access with the Super-X divertor configuration. The simulations incorporate equilibrium profiles, magnetic geometry, and plasma parameters representative of the pre-transition phase.

FELTOR, developed under the TSVV-3 project within EUROfusion, is a gyrofluid turbulence code designed for high-resolution 3D simulations of tokamak plasmas. It has been previously applied to the COMPASS tokamak [1] and the TCV-X23 campaign [3]. Recent code developments include the addition of synthetic diagnostics, such as virtual probes and synthetic Doppler Backscattering (DBS) signals [4], enabling direct comparison with experimental measurements and detailed analysis of turbulent structures.

Simulations are being carried out on the Leonardo supercomputing system at CINECA, Italy. Preliminary results reveal the emergence of filamentary structures that contribute to radial transport, particularly near the outboard midplane, consistent with a ballooning-like transport character. Ongoing analysis aims to quantify the associated particle and energy fluxes using synthetic diagnostics.

Figure 1 shows a snapshot of the electron density and electrostatic potential at t = 0.25 ms. The image captures outward-propagating filaments originating from the confined plasma region, highlighting the spatial localization of turbulent activity in the edge and scrape-off layer (SOL). These structures are being further analyzed through synthetic DBS signals to explore their role in mediating cross-field transport during the pre-L-H transition phase.

Future work will involve refining the synthetic diagnostic outputs, conducting a systematic comparison with experimental measurements, and exploring parameter sensitivities to inform validation and predictive modeling efforts.

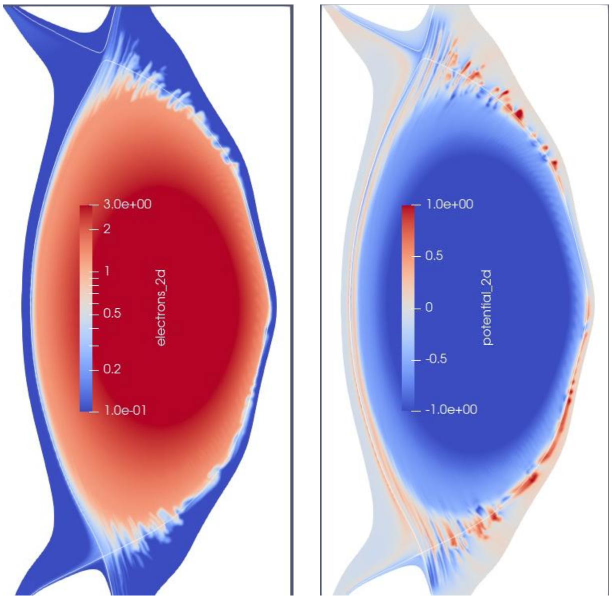

Figure 1 Feltor simulation using parameters from MAST-U #48004. The left plot shows the electron density, and the right plot shows the electric potential, both in normalized units. White lines denote the last closed flux surface, and black lines the numerical first wall.

References

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