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Electromagnetic full-f continuum gyrokinetic simulation of plasma turbulence in scrape-off layer of ASDEX Upgrade tokamak

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One of the burning open problems of achieving nuclear fusion within a magnetically confined device is mitigating the megawatt scale plasma outflux on the divetor plates of a tokamak. One quite promising approach is to spread the extreme steady-state power/heat load on the divertor plates via plasma turbulence. Turbulence broadens the heat-load onto a wider region on the divertor, thereby decreasing the per-unit-area heat-load on the plates. However, the scaling of the divertor heat-load profiles with the 'shape' and size of the tokamak is highly nonlinear and creates a pressing need for comprehensive ab-initio numerical simulation to acquire improved plasma confinement in existing tokamaks or, for the smarter design of future reactors to maximize fusion yield.

The prediction of density and temperature profiles in the 'edge' of a tokamak have always been challenging. The diverse effects of a plethora of turbulent modes, consequences of magnetic line bending, subtle numerical issues like Ampere cancellation demands a first principle kinetic simulation of SOL turbulence. Regardless of few recent ventures, a continuum electromagnetic simulation for the meticulous analysis of large amplitude intermittent fluctuations in the tokamak edge was still missing. Gkeyll being the first successful code to model tokamak edge with electromagnetic competence under the purview of continuum gyrokinetics with full-*f* capabilities, has been put to test to predict these density and temperature profiles for ASDEX-Upgrade tokamak. With minimal inputs from the experimental shots, the profiles of different plasma parameters are measured in numerical runs at a steady state. The simulation shows imprints of turbulence and predicts the particle and heat flux in the radially outward direction as well as onto the divertors.

We employ Gkeyll computational plasma framework [1], to carry out a careful analysis of scrape-off layer turbulence and compare our numerical results with the experimental data from Axially Symmetric Divertor Experiment (ASDEX) Upgrade tokamak (AUG) [2]. The AUG tokamak having a rich variety of plasma parameter measurements in the SOL region, facilitates comparison with the numerical results.

Gkeyll is the first successful electromagnetic gyrokinetic code on open field lines [1], has been efficiently employed to analyze the SOL turbulence in National Spherical Torus Experiment (NSTX) device. However, the plasma in SOL region being highly turbulent, smears quantitative extensions of results from one experimental device to the other, especially when the shapes and sizes of the geometry of plasma confinement differ.

The radial density and temperature profiles appear close to the ASDEX-U experimental measurements reported earlier. In addition, the spreading of heat load to the lower divertor is also measured. A density filamentation due to the curvature driven **E**X**B** drift is found to appear, and the radial propagation of such intermittent structures are measured as well. Statistical measurements of (for example, velocity, autocorrelation time, packing fraction and the detection frequency) of the density filaments are estimated and are found to be close to the experimental measurements

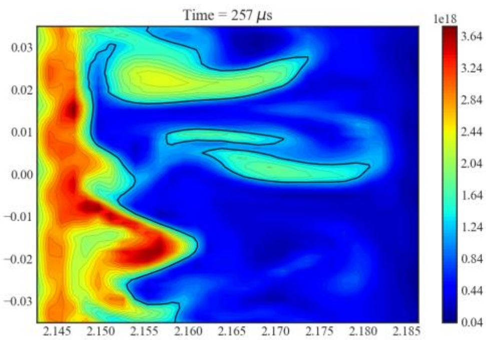

Figure: Gkeyll simulation for AUG-like parameters. Density filaments shear-off from the separatrix region and fill-out the SOL area.

References
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