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Comparison of Tokamak Plasma Mid-Plane with Divertor Conditions and Consequences for Modelling

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HESEL (Hot Edge SOL Electrostatic) model is a 2D energy conserving, four field model based on Braginskii equations. It solves for the electron density n_e, generalized vorticity ω_*, electron and ion pressure $p_{e,i}$. In the HESEL model, the tranport of plasma across the last closed flux surface is assumed to be concentrated in a poloidal region of 60° on the outboard mid-plane. Even though the parallel physics in the model is parametrized, the results are in qualitative agreement with the experimental observations. However, there are some constraints of the model and for experimental comparison.

The scrape-off layer, between the mid-plane and the divertor, is experimentally not well understood. Specifically, there is no experimental comparison of the ion temperature T_i fluctuation and no information about the parallel velocity of the plasma. To gain a better understanding of the behaviour of the plasma as it streams down from the outboard mid-plane towards the divertor, a new probe head (NPH) is currently built. An electron emissive probe, two Langmuir probes, two magnetic pick-up coils and two retarding field analyzers are integrated in the NPH. The main features of the NPH are the two retarding field analyzers, as it might then be possible to verify how the ion temperature evolves locally and how the fluctuations between the mid-plane and the X-point correlate. With the new probe mounted on the X-point manipulator of ASDEX Upgrade, it will be possible to insert it in the private flux region. This will allow the investigation of the filamentary transport towards the divertor and understanding of the spreading factor as related to diffusion in the private flux region. Since there are not many information from the X-point region, the NPH will be designed to allow basic measurements like electron and ion density, electron and ion temperature, the change of the magnetic field and the plasma potential.

Numerical simulations of the heat load on the NPH in the plasma of the scape-off layer were performed, putting emphasis on the temperature profiles of the holder at the end of the probe shaft and the inner part connecting the probe on top with the electrical connector. These two critical parts, made of Vespel SP1, are important as the material starts losing structural integrity at temperatures around 330°C. The simulation was carried out for the steady state case and for a transient heat load case. The probe was heated by setting a conservative heat flux at the interfaces. The results for the steady state case, showed that the Vespel SP1 holder does not reach temperatures above 300°C, meaning that the supporting function of the holder is not be compromised even if the NPH gets stuck completely in an extented position. The inner part reaches temperatures higher than allowed. In the more realistic transient case, the NPH is exposed to heating from plasma for a short time equivalent to a single plunge duration of 0.1 s. For this case it turns out that the simulated temperature of the shroud after one plunge in the plasma does not exceed 400°C. The support almost does not heat up at all and the temperature of the inner part stays below 300°C.

The NPH will be commisioned in ASDEX Upgrade for the 2018 campaign. In an ideal case, two identical probe heads will be installed in ASDEX Upgrade, one at the mid-plane and one at the X-point. The measurements are planned to be carried out in low confinement mode with density ramps.