Mechanisms affecting radial electric field in the SOL

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Abstract

Radial electric field (E_r) is the key parameter influencing turbulent and steady state plasma flows in the SOL. Its direct experimental impact on the plasma behaviour was demonstrated in biasing experiments, where externally induced E_r was shown to be capable of varying parallel/toroidal plasma flow and triggering a sudden change in perpendicular turbulent transport (L-H transition). Understanding mechanisms responsible for the E_r formation in the SOL is therefore an important prerequisite for interpretation and prediction of various transport phenomena in current and future fusion devices.

In a simple SOL theory, E_r originates due to the radial gradient of the Debye sheath across the limiter/target leading to the relation $eE_r \approx -3\nabla_r T_e$, where electron temperature is assumed to be constant along the field lines right up to the contact with material surfaces. The largest departure from this simple relation is seen in regimes with high recycling divertors, where neutral ionisation and charge-exchange lead to the appearance of several additional indirect contributions to E_r, via poloidal asymmetries. Among them are: thermoelectric force ($-0.71\nabla_{||}T_e$, for singly charged ions), ion-electron friction force $ej_{||}/\sigma$ caused parallel currents, and parallel electron pressure gradient $-\nabla_{||}p_e/n_e$. All these contributions are included in the main present-day 2D edge fluid codes. The codes also account for direct generation of radial electric currents due to ion-neutral collisions as well as radial drift fluxes, but ignore prompt ion kinetic losses and turbulent-driven contributions via Reynolds stress.

The talk will cover qualitative analysis of main contributions to the E_r formation in the SOL, and will include results of simulations of JET and ASDEX Upgrade plasmas with EDGE2D and SOLPS (B2.5-Eirene) 2D edge fluid codes, respectively. These results were recently compared with experimental measurements of E_r by reciprocating Langmuir probes and Doppler reflectometer (the latter – only for ASDEX Upgrade plasmas). Discrepancies in E_r values between the code results and experiments will be discussed, focusing on the possible role of missing physics in the codes.