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Radial Electric Field and Poloidal Impurity Asymmetries in the Pedestal of ASDEX Upgrade: Quantitative Comparisons between Experiment and Theory

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The formation of the H-mode transport barrier is strongly connected to the existence of a sheared plasma flow perpendicular to the magnetic field caused by a local radial electric field E_r. The strong gradients in E_r and the associated ExB velocity shear play a fundamental role in edge turbulence suppression, transport barrier formation and the transition to the H-mode. This contribution describes the nature and structure of the E_r well and its connection to H-mode confinement and discusses the impact of poloidal impurity asymmetries on the pedestal.
A detailed analysis of the edge E_r and kinetic profiles revealed that in H-mode E_r and the main ion pressure gradient term, grad(p_i)/(en_i), are identical within the uncertainties. This relation corresponds to the cancellation of the poloidal components of the ion diamagnetic and ExB drifts and suggests that in the pedestal the perpendicular main ion flow is close to zero. This result is confirmed by direct measurements of the main ion temperature, density and flow velocities in helium plasmas. The main ion poloidal rotation exhibits very small values at the plasma edge, as expected from neoclassical theory. The edge poloidal flow measurements of both main ions and impurities have been compared to a hierarchy of neoclassical models. In all cases, the measurements are found to be in quantitative agreement with neoclassical theory demonstrating that in the pedestal the E_r well is sustained by the gradients of the main ion species.
New charge exchange measurements at ASDEX Upgrade reveal the existence of a poloidal asymmetry in the flow pattern at the pedestal. The flow asymmetry can be explained by an excess of impurity density at the high-field side following the postulate of divergence-free flows on a flux surface. Comparison of the measured flows to theoretical predictions based on the parallel momentum balance reveals the nature of the parallel impurity dynamics. The key features of the experimental data including the shape of the rotation profiles and the poloidal impurity density asymmetry are reproduced quantitatively for the first time. The impact of these findings with respect to impurity transport at the plasma edge are presented.

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