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Ion heat and toroidal momentum transport studies in the H-mode transport barrier of ASDEX Upgrade

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The gradients in the ion and electron temperature profiles, Ti and Te, are a key component for driving turbulent transport in plasmas. Since the 1980s, 'profile resilience' has been observed on many tokamaks, which describes the fact that Ti and Te are limited by a critical normalized temperature gradient. Beyond this critical R/LT the heat diffusivities increase drastically. Hence, with stiff profiles the edge temperature is a key to attaining higher core temperatures and higher plasma confinement. Understanding the transport processes in the H-mode transport barrier, where turbulence is strongly reduced, is essential for a reliable scaling to next step fusion devices. In this contribution we analyze the ion heat and momentum transport at the plasma edge of ASDEX Upgrade (AUG) H-mode plasmas.

The experimentally determined ion heat diffusivities are compared to neoclassical theory and the impact of ELMs on the edge ion heat transport is studied in detail. During the inter-ELM phase the ion heat diffusivity in the pedestal region is close to the neoclassical level. High time-resolution CXRS measurements (100mus) enables detailed studies of the ion heat transport during the entire ELM cycle. The measurements show that during the ELM crash the radial ion temperature gradient flattens and the temperature close to the separatrix increases as a result of the ELM heat transport. The pre-ELM level in the ion heat transport is established approximately 2–3ms after the ELM crash.

In order to study the edge momentum an H-mode edge rotation database was created at AUG. The data reveals a strong dependence of the impurity toroidal rotation on the ion collisionality. Below a certain collisionality threshold the impurity toroidal rotation switches sign from co- to counter-current. The edge rotation is modelled using ASTRA. Here, the toroidal torque balance equation including diffusion, pinch and external momentum sources is solved. Comparison between the experimental profiles and the simulations shows good agreement within the experimental uncertainties, indicating that diffusion and external momentum sources are the dominant players. The sign change of the impurity toroidal rotation observed at low collisionality can be explained by a negative edge torque combined with a large differential toroidal rotation, while the main ion toroidal rotation is almost unaffected.

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