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Heat transport driven by the ITG and TEM instabilities in the ASDEX Upgrade tokamak

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Turbulence-driven ion heat transport in tokamak H-modes is driven by the ion temperature gradient (ITG) instability, while electron heat transport is driven by the ITG, trapped electron mode (TEM) and/or electron temperature gradient (ETG) instabilities. These three instabilities appear above their respective threshold in normalized temperature gradient (R/LT) and drive transport. We present results on the role of these contributions to heat transport in the ASDEX Upgrade tokamak.

We performed dedicated experiments with neutral beam injection (NBI) which heats both electrons and ions and electron cyclotron resonant heating (ECRH) which heats the electrons. From modulating of the electron temperature with ECRH we deduce the electron heat pulse diffusivity (chi_HP) which reflects the stiffness directly and is complementary to the power balance diffusivity (chi_PB).

The predicted dependences of the ITG-driven ion heat transport on Ti/Te and ExB rotational shear are found: the ITG is clearly more stable for high values of Ti/Te and/or rotational shear. The ITG threshold itself could not be assessed experimentally with accuracy yet and experiments are foreseen in the near future to improve this situation.

The electron heat flux is partly driven by the ITG, but when increasing the electron heat flux with ECRH above the flux driven by the ITG, the TEM and/or ETG instabilities become unstable which is particularly visible in the modulation data. Indeed, a moderate increase of chi_PB and a stronger increase of chi_HP above R/LTe = 5 indicates unambiguously that an electron instability (TEM or ETG) develops above this threshold. The stiffness is close to that found in ASDEX Upgrade for TEM-driven electron heat transport. Below the threshold, chi_HP and chi_PB exhibit about the same value of 1.5 m2/s. This rather high value is attributed to the ITG-driven electron heat transport, in agreement with chi_HP = chi_PB which reflects the fact that the ITG does not depend on grad(Te). So far, we have found no indication of an ETG contribution predicted to exhibit a stronger stiffness.

Transport modelling and comparisons of the experimental results with gyro-kinetic calculations will be presented for both the ITG and TEM/ETG studies.

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