PERTURBATIVE STUDIES OF ELECTRON TRANSPORT IN NSTX

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The electron thermal diffusivity in the National Spherical Torus Experiment (NSTX) spans an unusually wide range of values. At one extreme is the high power and density H-mode, where a broad region of nearly flat T_e around 1 keV forms in the plasma center a few hundred ms after beam turn on. Most of the T_e gradient occurs in the outer plasma half. Accordingly, the power balance calculations indicate a χ_e^{PB} in the range ≥ tens of m^2/s in the region of flat T_e, decreasing to the range ≤ 10 m^2/s in the region of strong T_e gradient. In addition, global crashes of the T_e profile having 5-15% amplitude are observed in these H-modes, a short time (1-1.5 ms) after the Type-I ELM perturbation.

At the other extreme of electron transport is the low density, shear reversed L-mode, where at a few hundred ms the T_e profile is mildly peaked at around 2 keV and χ_e^{PB} decreases to the range ≤ 2 m^2/s throughout much of the core.

To try and shed light on the mechanisms behind such a large variation we turned to perturbative transport studies. A good tool for controlled T_e perturbations was found to be the injection of small (≤ 1 mg), low velocity (≤ 150 ms) Li pellets. To measure the propagation of the 'cold pulse' we use in lieu of ECE, which is not applicable in the low field spherical torus, a multi-energy soft x-ray technique employing poloidal and tangential diode and 'optical' arrays.

The first experiments indicate a large difference also in the perturbed electron transport, between the low n_e L-mode and the high n_e H-mode. Injection of a 0.5 mg pellet in a low n_e, shear reversed L-mode heated by a 2 MW beam produces a substantial cold pulse in the outer plasma, but the negative T_e perturbation stops around mid radius, suggesting the existence of a strong electron transport barrier around q=1. Moreover, the SXR data indicates 'polarity inversion' of the pulse (i.e., positive T_e perturbation) inside the barrier, as sometimes seen in tokamaks. The T_e profile in these L-modes is therefore not stiff. In addition, the fact that reduced electron transport is so far seen only at low density seems to suggest that collisionality might also play a role in the NSTX electron transport.

The perturbed electron transport in a high density, 6 MW H-mode is radically different. The same 0.5 mg Li pellet produces a rapid, global collapse of the T_e profile, shortly after it penetrates the pedestal. The cold pulse propagation is remarkably similar to that observed following Type-I ELMs, with very fast propagation in the outer plasma half, followed by a slowing down in the inner plasma. The estimated χ_e^{pert} in the outer plasma is very high, suggesting that electron transport is well above a critical gradient. The slowing down of the cold pulse in the inner region, where the equilibrium T_e profile flattens, suggests however a substantial decrease in χ_e^{pert}, in interesting contrast with the above radial dependence of χ_e^{PB}.

Pending device availability, we will also report first results of experiments in which the influence of collisionality and beam heating power on the perturbed electron transport is investigated. We will also discuss the possibility of non-maxwellian electron energy distributions in the outer spherical torus plasma, suggested by the anomalously strong soft X-ray emission at E > 1.4 keV from the edge region.