§1. Comparative Studies of Magnetic Islands and Stochastic Layers in DIII-D and LHD

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During joint experiments on DIII-D and LHD we have discovered a spontaneous topological bifurcation of the O-point of a large static m/n = 2/1 magnetic island from smooth helical flux surfaces to a stochastic layer of approximately the same width as the original island O-point. We have made also direct measurements of the particle transport inside a static magnetic island located near the edge of the plasma. These results show that the physics of static magnetic islands is more complex than expected and has important implications for understanding the effects of externally driven magnetic islands on the confinement and stability in toroidally confined fusion plasmas. In this contribution we will describe results from joint experiments in the DIII-D tokamak and the LHD heliotron to characterize the effects of static edge magnetic islands on the heat and particle transport[1].

Particle transport inside a magnetic island was studied using hydrogen pellet in LHD. Figure 1 shows the effects of a hydrogen pellet injected into an edge static m/n=1/1 magnetic island produced by the LHD RMP coil. Here, the deposition of the pellet inside the island O-point results in a non-adiabatic evolution of the electron density and temperature. In this experiment pellets were periodically injected into the O- and X-point of a large island as well as into plasmas with no RMP induced islands. The island electron density decay rate $\Delta n_e/\Delta t$ was measured using a line-integrated CO2 laser imaging interferometer in each of these cases and charge exchange recombination data was obtained which provides information on changes in the toroidal and poloidal flows, impurity pressure gradients and radial electric fields. It was found that the electron density decay rate goes through two separate phases in all cases. There is a fast exponential decay during the first 80 ms followed by a much slower decay. During the initial electron density decay, for a pellet placed inside the island O-point and with $\Delta n_e/\Delta t$ averaged over the first 80 ms, $\Delta n_e/\Delta t$ was found to be $7.5 \times 10^{20}\mathrm{m}^{-3}\mathrm{s}^{-1}$. This is about a factor of 2 larger than the initial $\Delta n_e/\Delta t$ with a pellet injected into an X-point or with a pellet in a discharge with no RMP.

In this experiment, radial profiles of the electron density and temperature were measured at discrete time intervals with the LHD Thomson scattering system. As shown in Fig.2(a), the electron density inside the island increases from $3 \times 10^{19}\mathrm{m}^{-3}$ at 4.07 s, just before a pellet is injected into the outer edge of the discharge, to $8.4 \times 10^{19}\mathrm{m}^{-3}$ at 4.10s just after the pellet is injected. This shows that the peak density inside the island can exceed the central density in the discharge by at least a factor of 2.2. It is noted that some of the pellet mass is carried across the island and deposited on flux surfaces closer to the core of the plasma. This produces a smaller secondary peak in the density profile at $r_{\mathrm{eff}} = 0.4$ m. During the initial fast density decay between 4.10 and 4.13 s this smaller density peak located on the inboard side of the island shows a significantly slower decay rate than that inside the island O-point. A characteristic flattening of the Te profile across the island is seen in Fig. 1(b). After the pellet enters the island O-point at 4.10 s the entire Te profile drops by about 250 eV. As the density in the island O-point drops, between 4.10 and 4.15 s, Te remains relatively constant indicating a non-adiabatic change in the pressure inside the island due a higher electron particle transport than heat transport. Data from both MECH and island pellet experiments are providing valuable insight into the structure of edge islands and transport due to the islands that can be used to determine whether the islands are screened or amplified in diverted H-mode plasma and if they are involved in modifying the stability of the peeling-ballooning modes that are believed to be responsible for ELMs.

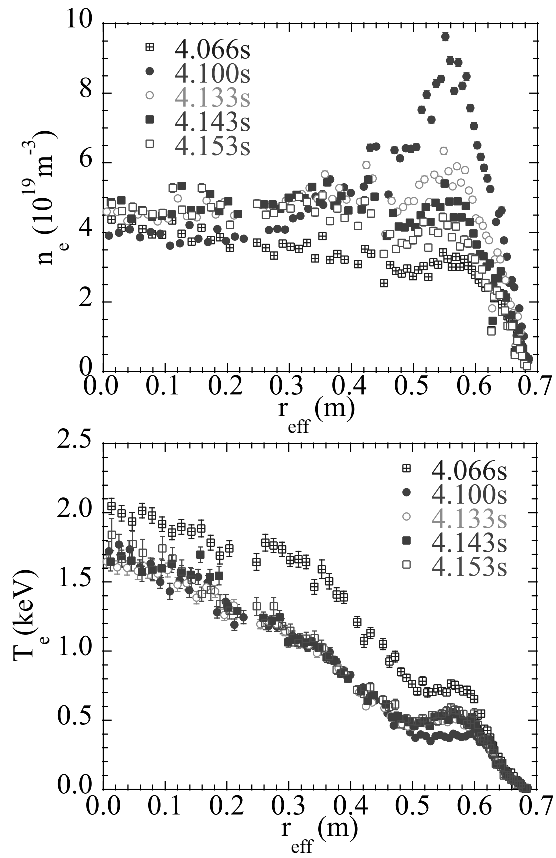

Fig. 1: profiles of (a)electron density and (b)electron temperature in after the injection of an Hydrogen pellet.

1) K.Ida et. al., New J. Phys. **15** (2013) 013061