§2. Effects of Core Magnetic Islands to Edge Magnetic Topology

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This experiment was done as part of a collaboration between DIII-D and LHD to expand our physics basis for the effects of the magnetic topology on transport, stability and plasma-surfaces interactions. In DIII-D it is found that locked $(m, n) = (2, 1)$ core magnetic islands causes a non-axisymmetic distribution of the heat and particle flux on the divertor target plates. It has been hypothesized that a helical current in the $(2, 1)$ island perturbs the axisymmetric separatrix resulting in the toroidally asymmetric distribution. If this is the case, the $(2, 1)$ helical magnetic field from the current in the locked mode acts on the separatrix in the same way as the 3D field from external magnetic perturbation coils used to suppress ELMs and correct field-errors.

The LHD experiment was proposed as a test of this mechanism. Here, the idea is to use the RMP coils on LHD to produce a core $(m, n) = (2, 1)$ island and then drive a current in the island using the NB and ECCD systems. It was expected that the RMP coils would also produce a larger edge $(m, n) = (1, 1)$ and that the helical current in the $(2, 1)$ island would alter the topology of the $(1, 1)$, island causing a change in the divertor heat and particle flux distributions. In order to establish the best current drive coupling to the $(2, 1)$ island, various combinations of NB and ECCD configurations were used including: co-NB only, co-NB plus co-ECCD, counter-NB only and counter-NB plus counter-ECCD. In addition, different RMP coil configurations were used such as: (+,0,-), (-,0,+), (0,0,+) and (+,-,0) and the current in the coils was changed in order to optimize the coupling between the core and edge islands.

As the first series, the magnetic configuration is set to (R_{ax}, B, γ, B_q) = (3.6m, -2.75T, 1.2538, 100%). The goal of this series was to clearly identify a large $(2, 1)$ using a flattening of the Te profile form the Thomson scattering system as the primary diagnostic. A density scan was attempted with changes in the NB, ECCD and RMP coil configurations. Calibration discharges were run for MSE and for magnetics. It was found that the $(2, 1)$ island was difficult to identify using the Thomson scattering data due to its toroidal phase with x-point located neat the Thomson scattering port (4O) and an apparently small size with the plasma parameters being used. Although a substantial NB current was being driven ($\sim$100 kA) this did not appear to enhance the island size or cause an observable change in the $(1, 1)$ islands (based on the control room analysis).

As the next series, the magnetic field is changed to B=-1.375T. This series was proposed in order to increase b with the expectation that higher b would cause significant changes in the islands that could then be compared with the results from series 1. A similar sequence of discharges was used as in series 1. After reducing the toroidal field it was found that a flattening due to the $(2, 1)$ island became much more visible on the Thomson scattering data. In addition the $(1, 1)$, island was significantly larger than with the higher toroidal field used in series 1 and it appeared that some additional islands, possibly $(3, 2)$ were being generated for some coil and NB configurations. A number of interesting cases were identified that appeared to have the characteristics needed to modify the divertor. One example is discussed below.

In figure 1, the particle flux in the divertor is shown. The time of interest in this discharge is between 4 and 9 s during the NB2 beam injection. the particle flux distribution in the divertor changes. At the same time, the response of the m=1 and m=2 modes during this time is seen in the magnetic diagnostics. The change in the $m = 1$ and $m = 2$ mode amplitudes are correlated with the turn on the perpendicular NB4 and 5 CXS beams. These results suggest that the amplitude of the m=1 and 2 modes are affecting the divertor particle flux distributions but it is not yet clear how the distribution is related to the topology of the $(1, 1)$ and (2.1) modes. Additional analysis and modeling is needed to address this question.

In summary, this experiment resulted in effects that appear to be related to those seen in DIII-D during locked modes. A detailed analysis of the data is expected to give us new insight on how core modes couple to the edge magnetic topology and affect the divertor conditions in toroidal confinenet systems.

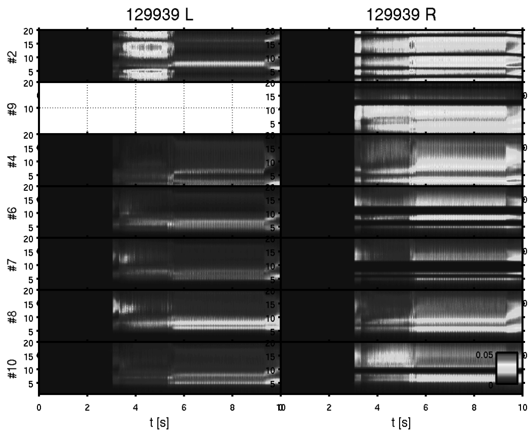

Fig. 1: Some divertor Langmuir probes show a high particle flux before the change in the $m = 1$ and $m = 2$ mode amplitudes while others show a low particle flux. When the modes change the particle flux seen by each of the probes reverses from high to low and from low to high.