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Electron internal transport barrier induced by neoclassical tearing mode in the ECRH plasma on J-TEXT

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Understanding the electron thermal transport is essential for the magnetic confinement fusion plasmas, since the fusion-born alpha particles mainly heat the electrons in a fusion reactor. For more than a decade, it has been believed that magnetic island structure can be responsible for the trigger of internal transport barrier (ITB) at rational surface and hence improves plasma confinement [1]. In the ECRH plasmas on J-TEXT, the increase of neoclassical tearing mode (NTM) amplitude has been observed to induce the reduction of the core electron thermal transport with the formation of an electron internal transport barrier (ITB) [2] just inside the island inner separatrix.

At medium NTM amplitude, the ITB is formed with a dithering phase, i.e. plasma transitions from no transport barrier to ITB or vice versa quasi-periodically. With NTM amplitude further increasing, the dithering ITB transitions into a steady ITB. The steady ITB can last for over 0.3 s (limited by the discharge duration), which is more than 2.5 times current diffusion time. The electron temperature gradient inside ITB increases with NTM amplitude.

The trigger of ITB and further enhancement of ITB performance are also demonstrated by locking the island via applying a resonant magnetic perturbation (RMP) field. The confinement energy with improved ITB can recover to the level prior to the appearance of the magnetic islands. The reduction of density fluctuations in ITB region is observed and indicates the turbulence suppression during ITB formation. The ITB can also be triggered with the formation of 3/2 locked island due to the penetration of 3/2 RMP [3]. By applying external rotational transform field [4], the rotating NTM can be suppressed while the ITB is maintained with significant increase of core T_e. These findings offer new insights for understanding ITB formation and robust ITB control.

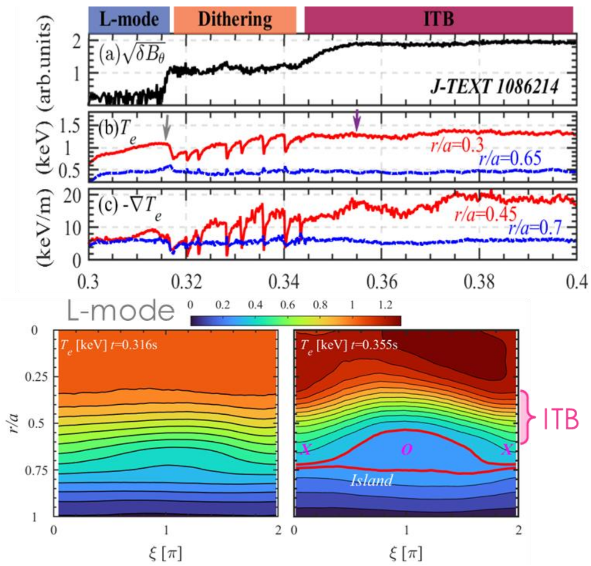

Figure. Transition from L-mode to dithering ITB and steady ITB, and T_e contour versus island phase and radial locations for L-mode and ITB.

References

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