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Study of Edge Plasma Characteristics at H-mode Transition in Heliotron J

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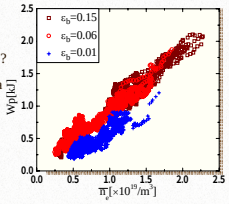
Introduction

- We have been studying the optimization of the magnetic field configuration by unique and flexible configuration control in the Heliotron J device.
- High confinement mode transition has been observed in Heliotron J plasma. The transition phenomenon is dependent on the field configuration. The transition phenomenon tend to arise at low bumpiness configuration (B_{04}/B_{00} = 0.01) rather than at high bumpiness configuration (B_{04}/B_{00} = 0.15). However plasma performances at the high bumpiness configuration can maintain higher n_e and Wp than at the low bumpiness configuration.

➡ Why does the low bumpiness configuration tend to excite a high confinement mode despite the hardness to reach higher n_e and Wp ?

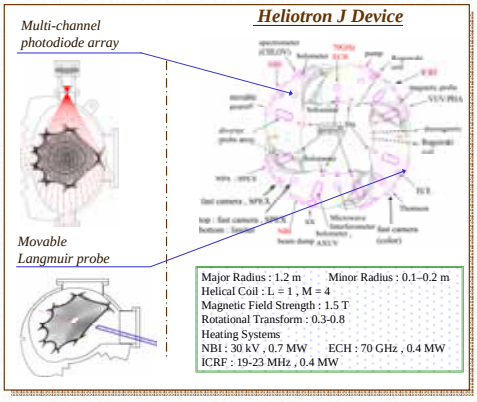
➡ Understanding the internal plasma structures with high confinement transition mode is a key issue to clarify physics of transition phenomenon in helical systems.



Objectives

- We identify the change region of plasma profiles in the transition at various bumpiness configurations in Heliotron J.
  - ✓ The plasma profiles is estimated by using a multi-channel photodiode array.
- We investigate the characteristics of edge plasmas during L/H transition at the standard configurations (B_{04}/B_{00} = 0.06).
  - ✓ The bursty characteristics on SOL is analyzed by using the probability distribution function (PDF).

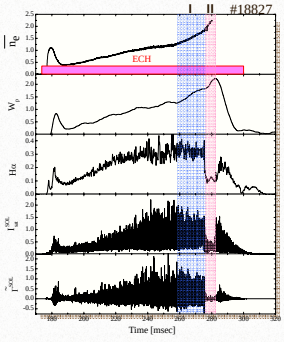
Heating and Diagnostic systems for Heliotron J



- A multi-channel photodiode array is installed in the corner section. The multi-channel photodiode array has 20 channel lines of sight, covering the photon energy from the visible to the soft-X ray region.
- The Langmuir probe consists of 5 pins, having the time resolution of 1 μs. The 2-pins is a double probe, is used for measuring the ion-saturation current. The other 3-pins is set to measure the floating potential.

H-mode transition at STD configuration

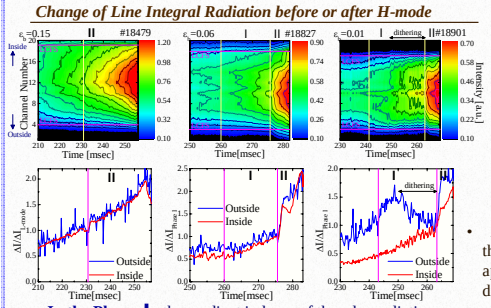
- H-mode (Phase Ⅱ) is followed by the phase (Phase Ⅰ) in which Wp increases changes modestly.
- The averaged electron density increases modestly, and Wp is doubled in Phase Ⅰ and Ⅱ.
- The H_α signal at the edge region drops down at the transition time in Phase Ⅱ.
- The particle flux across the separatrix decreases, which are estimated by an ion saturation current at the scrape off layer in Phase Ⅱ.
- These changes are observed in other configuration as well as the STD configurations. However, there is not Phase I at the high bumpiness configuration.



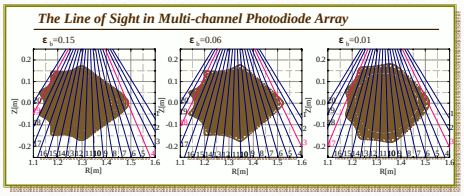
- The turbulence induced radial particle flux on SOL is suppressed in Phase Ⅱ

Change of Radiation Profile during L/H Transition in Heliotron J

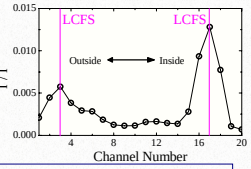
Change of Line Integral Radiation before or after H-mode



The Line of Sight in Multi-channel Photodiode Array

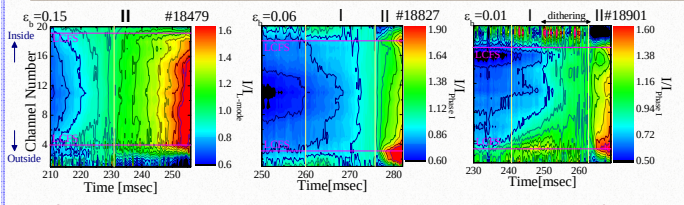


- **In the Phase Ⅰ**, the gradient indexes of the edge radiation profile increase near LCFS, and become asymmetric at low bumpiness configurations.
- **In the Phase Ⅱ**, the plasma radiation increases at the inside of plasma, and the gradient indexes increase rapidly at low and medium bumpiness configurations.
- At low bumpiness configuration, the large radiation fluctuation appears around the LCFS in the dithering phase. The edge radiation profile is asymmetric in the phase.



- The radiation profiles change modestly on edge plasma in Phase I, and the gradient index increase largely on near LCFS in Phase II .

Change of Radiation Intensity at each channel after the H-mode Transition

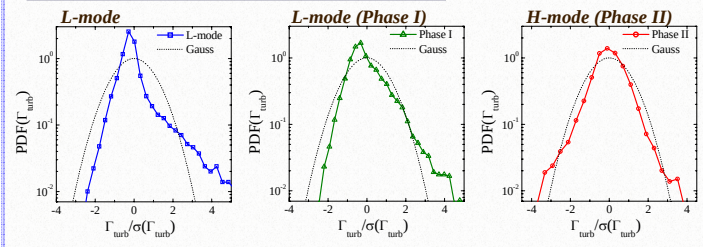


- The transition affects the edge plasma structure.
- The change in the transition suggests the change of the plasma structure near LCFS.

- ***After the H-mode transition***, the radiation sharply decreases in channels of the SOL at each configurations, after that it increases asymmetrically in the poloidal section around LCFS at the medium and low bumpiness configurations.

Bursty Fluctuation Characteristics in the Edge Plasma during L/H Transition

Medium bumpiness configuration (ε_b=0.06)



- As the fluctuations have a random characteristics, the PDF should be a Gaussian profile, but as the turbulence fluctuation arise intermittent, it distorts Gaussian distribution.

- In the Phase Ⅰ, the tail of PDF for the fluctuation induced particle flux becomes small with time.
- In the Phase Ⅱ, the PDF are nearly Gaussian. The bursty particle transport are suppressed in phase II.

Discussion

- The change of the edge radiation profile exists before H-mode transition at medium and low bumpiness configurations.
  - ➡ The change of the edge profile may be related to the trigger of the H-mode transition.
- The change of radiation intensity sharply decreases at the scrape off layer and increase at the LCFS after the H-mode transition.
  - ➡ The edge transport barrier may be formed at the edge plasma in the H-mode transition.
- The dithering phase exist before H-mode transition at low bumpiness configuration, and the radiation profile is a asymmetric in these Phases. These are different from the Phase Ⅰ characteristics at medium bumpiness configuration.
  - ➡ The asymmetric change at the edge plasma may be related to the H-mode transition.

Conclusion

- Plasma radiation profiles has been measured by using the 20 channel photodiode array before and after the H-mode transition at various configurations.
- The plasma radiation drops down in the scrape off layer at the H-mode transition, after that it sharply increases near LCFS.
- The change of the radiation profile during L/H transition depends on the configuration.
- The gradient index in radiation profile near LCFS increases rapidly after the transition at medium and low bumpiness configurations.
- The bursty radial particle transport are suppressed after the transition.
- The edge radiation profile might be relate to the turbulence transport in the SOL.