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Observation of a pedestal quasi-coherent mode with LHCD in type-I ELMy H-mode of the HL-2A tokamak

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In magnetic fusion devices, high confinement mode (H mode) always forms edge transport barrier with steep gradient, namely pedestal. The high pressure gradient and high current density of pedestal could provide free energy for exciting instabilities, such as edge localized modes (ELMs), which will lead to the rapid collapse of pedestal structure, and simultaneously lots of particles and energy will be erupted to the first wall and divertor targets in a short time. Therefore, it is very meaningful to understand and control the pedestal dynamics and the evolution process of ELM burst, especially for the design and operation of future fusion reactors.

It is found that the quasi-coherent mode (QCM) in pedestal may play an important role in regulating the pedestal structure. The previous study on HL-2A indicates that the pedestal QCM can regulate pedestal particle transport where the resistive ballooning mode is the candidate instability as predicted by BOUT++ [1,2]. Recently, a few H mode discharges with type-I ELMs have been carried out through two NBI lines together with the lower hybrid wave (LHW) heating. A QCM was observed after L-H transition but before the first ELM burst. It was found in density fluctuations and radial electric field fluctuations. Shown in figure 1, the characteristic frequency of QCM gradually decreases from 50kHz to nearly 20kHz before the first ELM. At 850ms when the LHW heating was switched on, the core MHD in figure 1(c) disappeared and the QCM was excited at the same time. The above MHD is the m/n=1/1 continuous fishbone instability which located around the q=1 surface.

According to the analysis, the observed QCM has the following characteristics. 1) it exhibits only strong electrostatic fluctuation components. 2) it is localized in the pedestal region. 3) the excitation of QCM is related to the LHW heating. 4) the radial wave number of the QCM is $k_r \sim 0.8\ cm^{-1}$ and it is radially propagating outward. The poloidal wave number is $k_\theta \sim 1.4\ cm^{-1}$ and propagates in electron diamagnetic direction. 5) QCM's characteristic frequency is linearly related to the change of edge toroidal velocity, presented in figure 1(b). 6) the particle transport was gradually enhanced during the existence of the QCM. It has prolonged the ELM-free state to about 44 ms, and this QCM could play a key role in regulating particle and energy transport, thus sustaining the high confinement. This report will discuss about the QCM formation and its relationship to ELMs and ELM-free, as well as the mechanism of interactions with each other.

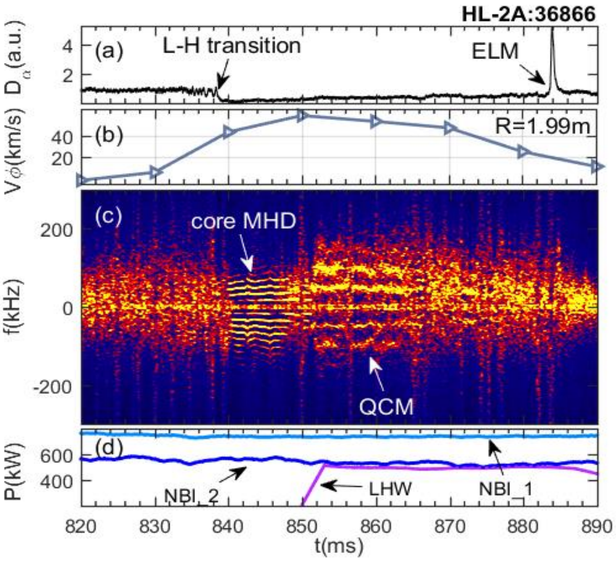

Figure 1. (a) Divertor D_α signal. (b) Toroidal velocity of edge plasmas detected by CXRS. (c) Time-frequency spectrum of Doppler reflectometer's signal at pedestal region. (d) NBI and LHW heating

References

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