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ビーム放射分光計測を用いたDIII-Dトカマクの Wide pedestal quiescent H-modeにおける広帯域乱流揺動特性解析

Analysis on broadband turbulence measured with beam emission spectroscopy in wide pedestal quiescent H-mode on DIII-D

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Suppression or avoidance of Edge Localized Modes (ELM) in the high performance regime (H-mode) is quite important, as ELMs could produce unacceptable damage to divetor plates and first walls in a large-scale fusion device. One possible operational mode with tolerable divertor heat load is the quiescent H-mode (QH-mode) [1], which exhibits H-mode confinement at constant density and radiated power without any ELMs due to enhanced particle transport by an electromagnetic edge harmonic oscillation (EHO). The EHO is thought to be driven by current and additionally destabilized by rotational shear.

Recent years, a new QH-mode regime with wider pedestal has been achieved in DIII-D [2]. The standard QH-mode state bifurcates into the wide-pedestal state by a sufficient reduction of input torque, exhibiting a spontaneous transition from the coherent EHO to the broadband MHD turbulence state as shown in Fig. 1. It is thought that ExB rotational shear altered by changes in torque affects the edge turbulence state and associated radial transport, leading to the wider pedestal. Clarifying the characteristics of the turbulence is one of the important issues to understand the mechanisms of formation of the improved pedestal condition. The broadband MHD turbulence is typically observed in low frequency range up to ~100 kHz with magnetic probes and Beam Emission Spectroscopy (BES), and has been found to be composed of two components in terms of toroidal mode number; a lower frequency band with negative toroidal mode number and a higher frequency band with positive toroidal mode number. While the mode with positive toroidal mode number exists before and after the transition from the standard phase to the wide-pedestal phase, the mode with positive toroidal mode number is only seen after the transition, and is spectrally quasi coherent. The nature of the quasi-coherent mode such as the radial localization and the temporal behavior was evaluated by using 2D multi-channel BES measurement. It is found that the QCM exists over the pedestal and peaks around zero ExB shear region and its amplitude oscillates at f ~ 250 Hz in phase with oscillation of divertor D_α emission intensity which is observed after the transition into wide-pedestal phase as shown in Fig.2.

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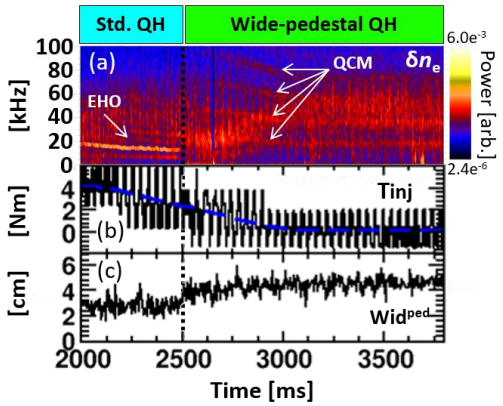

Figure 1. Time evolution of QH-mode plasma (163519) showing transition into wide-pedestal QH phase at ~2500 ms: spectrogram of (a) density fluctuation; (b) NBI torque (black) and its smooth curve (blue) and (c) pedestal width.

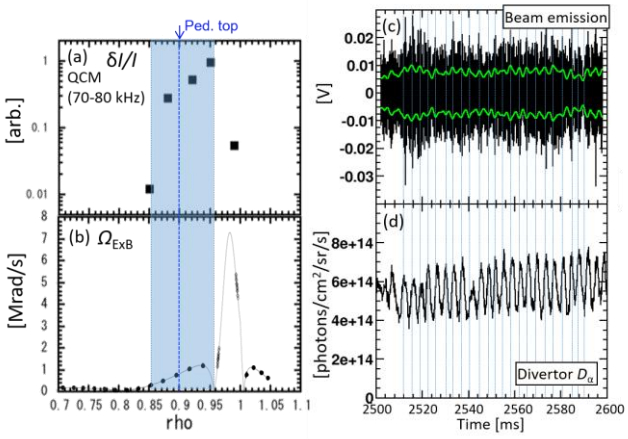

Figure 2. Profiles of the QCM amplitude (70 < f <80) and (b) ExB rotational shear. Time evolution of (c) beam emission intensity for the frequency range including the QCM (black) and its envelope (green) and (d) divertor D_α emission intensity.

[1] Burrell K H, *et al* 2009 *Nucl. Fusion* **49** 085024
[2] Burrell K H *et al* 2016 *Phys. Plasmas* **23** 056103