§14. Observation of the 2D Structures of the ELM-like Phenomena Using a Tangentially Viewing VUV Imaging System in LHD

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In the improved confiment regime (H-mode) of LHD, the onset of a quasi-periodic series of relaxation oscillations involving bursts of MHD activity and D_α emission can be observed, which is called edge localized modes (ELMs) phenomena. Such oscillations causes rapid losses of particles and energy from the region near the plasma boundary, consequently, resulting in the reduction on the average global energy confinement. Up to 20% of the plasma stored energy can be expelled by ELMs with large amplitude from the edge transport barrier (ETB) region in LHD [1]. Therefore, understanding the cause of the ELM phenomena is required to control its amplitude and nature.

In LHD, a tangentially viewing high-speed vacuum ultraviolet (VUV) imaging system has been developed [2, 3], which selectively measures the C VI line emission (13.5 nm), and mainly focuses on the density fluctuations caused by low-frequency MHD events. This system is good for investigation on edge plasma activities since the C VI emission is mainly localized at the peripheral region in LHD plasma. In the H-mode plasmas with ELMs, the repetitive increases in the C VI emission caused by the ELM activities have been measured successfully by the VUV imaging system. Fig. 1 shows the typical plasma waveform. The L-H transition occurs at about 4.87s. In the H phase, plasma stored energy increases, and quasi-periodic large amplitude bursts on H_α and C VI line emission, which are typical experimental characteristics of ELM activities, are observed.

In the present work, the key components of the perturbations caused by the ELM event are obtained by performing the singular value decomposition (SVD) on the measured VUV imaging data. And the decomposed images are independent with the time window used for the SVD analysis. Fig. 2 (a) shows the Chronos of the first two components and the temporal evolution of H_α emission. The bursts are caused due to the ELM event. The two-dimensional (2D) spatial structures are estimated by comparing the experimental measured VUV images and synthetic images using plausible emission profiles, as shown in Fig. 2 (b). The increase in the C VI emission due to ELMs is poloidally asymmetric: the increase is larger at the locally low field side (both inboard and outboard sides in the horizontally elongated section of LHD) than that at the high field side (upper and lower side of the section). That is, the plasma distortion caused by ELMs extends mainly in the lower magnetic field side at ELM like events, which is similar to the Tokamak ELMs.

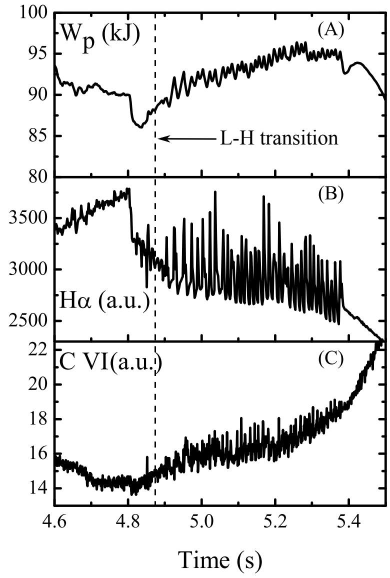

Fig. 1: Typical plasma waveform with ELMs: (a)plasma stored energy, (b)H_α emission, (c)C VI emission measured by VUV imaging system

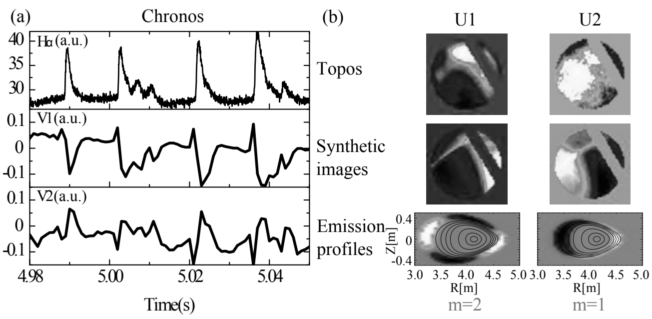

Fig. 2: (a)Temporal evolutions of H_α emission and Chronos of the first two key components (V1-V2), (b) Topos of the first two components (U1-U2), synthetic images and corresponding plausible C VI emission profiles

1) K. Toi *et al.*, "Mitigation of Large Amplitude Edge-Localized-Modes by Resonant Magnetic Perturbations on the Large Helical Device", 24 th IAEA CN-197, EX/P4-10.

2) M. Takeuchi *et al*, "Development of a High-Speed VUV Camera System for 2-Dimensional Imaging of Edge Turbulent Structure in the LHD", Plasma Fusion Res. 5 (2010) S1037

3) T.F. Ming *et al*, "High speed vacuum ultraviolet telescope system for edge fluctuation measurement in the large helical device", Review of Scientific Instruments, Vol.83, Issue 10 (2012) 10E513.