§50. Observation of Hα Fluctuations Related to Alfvén Eigenmodes in Large Helical Device

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Confinement of energetic ions is important for efficient heating and simulation of alpha particle in existing magnetic confinement systems. However, steep pressure gradient of energetic ions cause energetic ion driven instabilities such as TAEs[1] and EPMs[2]. Information on radial structure of the instabilities is strongly required to clarify characteristics of instabilities and their impacts on energetic ion confinement. These instabilities would induce electron density fluctuations. For measurement of the density fluctuations, a detector array of Hα emission with fast response up to 250 kHz was installed on LHD. The Hα emission in a plasma with energetic ions will be proportional to $n_n n_e \langle \sigma_{ex} v_e \rangle + n_n n_{fast} \langle \sigma_{ex} v_{fast} \rangle$, where one comes from electron-impact excitation and the other from energetic-ion excitation. Here n is the particle density, v is the particle velocity, $\langle \sigma_{ex} v \rangle$ is the excitation rate coefficient. Subscript "n", "e", and "fast" indicate neutral, electron, and fast ion, respectively. Electron impact excitation is dominant; but that by fast ions will have some contributions. Hα fluctuations reflect n_{fast} fluctuation as well as n_e fluctuations. Energetic ion driven MHD modes such as TAEs and EPMs would modulate n_e and n_{fast} with the same frequency. Accordingly, radial profile of Hα fluctuations would give information on the radial profile of these MHD instabilities.

A Hα detector array having high frequency response up to 200 kHz was installed to detect fluctuations related to TAEs and/or EPMs. Its line of sight is shown in Fig.1. Upper 8 detectors view from ρ ~0.3 to outside of a plasma, and lower 6ch detectors view from ρ ~0.2 to the outside. These detectors can monitor not only edge part of plasma but also inner part of the plasma, and derive spatial structures of these instabilities.

In high beta plasma produced with intense neutral beam injection, coherent Hα fluctuations having high coherence with magnetic fluctuations of TAEs were observed (Fig.2). In this figure, the contour of the magnitude of coherence between the Hα signal and magnetic probe signal is also shown. Several fluctuations with high coherence are clearly identified on the contour plot. The excess of the coherence for the background coherence due to incoherent fluctuations Δ_{coh} is shown in Fig.3 as a function of the normalized minor radius. The sharp peak of Δ_{coh} locates in the peripheral region of a plasma (0.5<ρ<0.8) for three typical coherent modes with a characteristic frequency of 27-32, 35-55 and 68-83 kHz. The peak poisons agree with the predicted TAE modes with the toroidal mode number of n=1 or n=2.

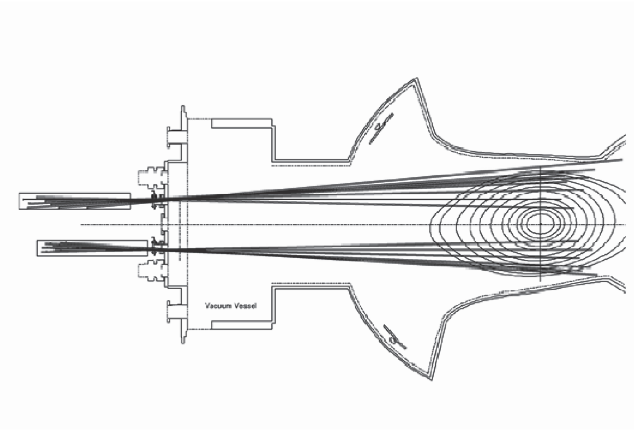

Fig.1 Hα detector array, and its line of sight. Frequency response up to 200kHz.

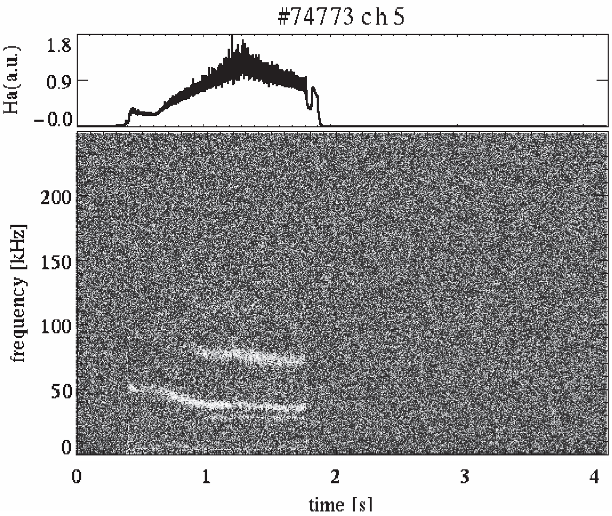

Fig.2 Hα signal and Hα fluctuation coherence with magnetic fluctuation of TAEs.

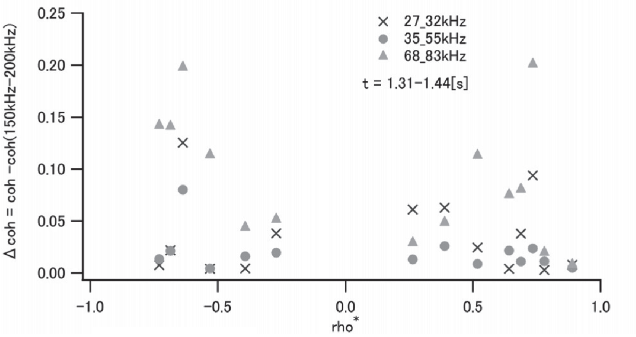

Fig.3 Space structure of Δcoh.
Δcoh is high at 0.5<ρ<0.8

Reference
1) C.Z. Cheng *et al.*, Phys. Fluids **29**, 11 (1986)
2) Liu Chen, Phys. Plasmas **1**, 5 (1994)