§62. Recurrent MHD Bursts Observed in LHD ECRH Plasmas with Suprathermal Electrons

Isobe, M., Ogawa, K., Shimizu, A., Kubo, S., Osakabe, M., Toi, K.

MHD instabilities associated with energetic ions produced by neutral beam injection (NBI) or ion cyclotron resonance heating has been intensively investigated in magnetically confined fusion experiments in the world. After fishbone (FB) instabilities driven by barely trapped suprathermal electrons produced by off-axis ECRH were found in DIII-D [1], several different types of instabilities associated with suprathermal electrons have been widely recognized in many devices [2-5], providing a good opportunity to obtain deeper understanding of excitation mechanism of energetic-particle-driven MHD instabilities. Recently, MHD instabilities associated with suprathermal electrons have been observed in LHD [2]. Two different magnetic fluctuations have appeared in LHD ECRH plasmas. One is the coherent fluctuation in an acoustic range of frequency. It looks that this mode is classified into most likely BAAE or BAE, not EGAM because toroidal mode number n is not zero [5]. Another is the FB-like recurrent MHD burst. In this report, the latter observational result is described.

To study suprathermal electron behavior in LHD plasmas, two compact CsI(Tl) scintillation detectors (1 cm x 1 cm) coupled with a photodiode have been recently installed on the lower diagnostic port at the vertically elongated poloidal cross section, covering a detectable energy range from ~50 keV to ~2 MeV. One has a line of sight viewing plasma center and another has a line of sight only for the edge region. Each detector is mounted inside a stainless steel collimator and measures hard X-rays (HX) through a thin blank flange having thickness of 3 mm. Typical HX energy spectra in an 2nd harmonic ECRH plasma without NBI and an NBI plasma without ECRH are shown in Fig. 1. As can be seen, HX of which energy is up to ~400 keV is detected in the ECRH plasma with line-averaged electron density $<n_e>$ of ~0.5×10^{19} m^{-3}. This fact tells us that suprathermal electrons surely exist in the 2nd harmonic ECRH plasma of our interest. HX flux and energy depend on electron density as expected. HX energy tends to decrease as $<n_e>$ is increased and has not been detected if $<n_e>$ reaches 1×10^{19} m^{-3}. When $<n_e>$ is decreased below 0.5×10^{19} m^{-3}, the existing HX system suffers a pulse pileup issue because of high flux of X-rays but measurements suggest that HX flux and energy increase obviously in ECRH plasmas with $n_e<0.5 \times 10^{19}$ m^{-3}.

Fishbone-like recurrent MHD bursts often appear in an extremely low-n_e off-axis ECRH discharge ($n_e<0.1 \times 10^{19}$ m^{-3}) at B_t/R_{ax} of 1.51 T/3.6 m (see Fig. 2). Correlated with each MHD burst, the heavy ion beam probe indicates that potential changes to more positive at the core region (r/a~0.55). Note that coherent fluctuation on the potential signal has not been visible so far in concerned plasmas. Pulsatile potential change to positive is supposed to be due to rapid expulsion or radial transport of suprathermal electrons [6]. To verify this hypothesis, reduction of HX flux reaching the scintillation detector is required because the detector count rate has been normally over the maximum counting rate capability in 2nd harmonic ECRH plasmas ($n_e<0.5 \times 10^{19}$ m^{-3}). The existing collimator set is going to be improved so as to reduce counting rate of the detector toward the 16th experiment cycle.

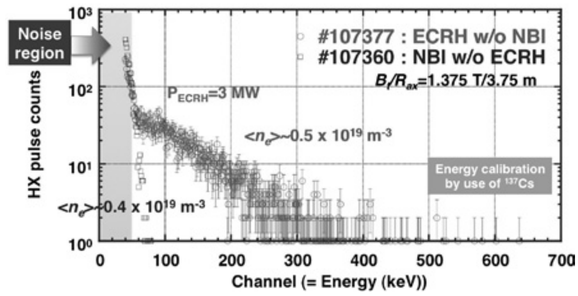

Fig. 1. Hard X-ray energy spectra measured in 2nd harmonic ECRH plasma without NBI and NBI plasma without ECRH in LHD. Two spectra are measured with the CsI(Tl) detector having a central line of sight.

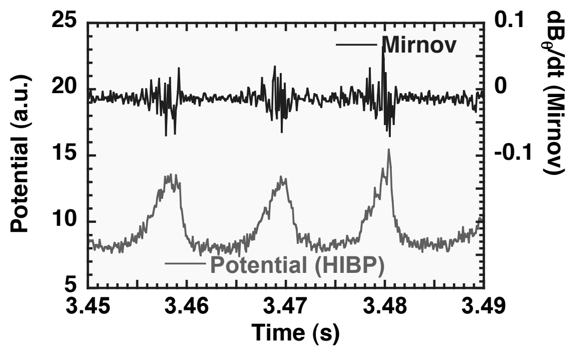

Fig. 2. Fishbone-like recurrent MHD bursts and associated positive increase of plasma potential at the core region (r/a~0.55) in the 2nd harmonic ECRH plasma of LHD.

1) Wong, K.L. et al.: Phys. Rev. Lett. **85** (2000) 996.
2) Ding, X.T. et al.: Nucl. Fusion **42** (2002) 491.
3) Snipes, J.A. et al.: Nucl. Fusion **48** (2008) 072001.
4) Deng, C.B. et al.: Phys. Rev. Lett. **103** (2009) 025003.
5) Isobe, M. et al.: Nucl. Fusion **50** (2010) 084007.
6) Isobe, M. et al.:12th IAEA Technical Meeting on Energetic Particles in Magnetic Confinement Systems, Sep.7-10, 2011, Austin, Texas, US, **O-20**.