§42. MHD Instabilities Destabilized by Suprathermal Electrons in Low Density ECRH Plasmas of LHD

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Energetic-particle-driven MHD instabilities such as the fishbone mode and Alfvénic modes have been one of key physics issues in magnetically confined fusion plasma experiments because those instabilities may cause anomalous transport and/or loss of energetic particles. Experiments on this subject have been so far carried out by use of beam ions, perpendicular energetic ion tail produced by ICRH and alpha particle created by D-T reaction. Suprathermal electrons are also capable of destabilizing those modes since excitation of those modes depends on precessional drift frequency of particle, not on mass [1].

Instabilities destabilized by suprathermal electrons created by ECRH and/or LH have been seen in several tokamak and helical devices [2-4]. In CHS, bursting recurrent MHD instabilities driven by trapped suprathermal electrons were observed in low-density (n_e<5x10^{18} m^{-3}), 2nd harmonic ECRH plasmas (f_{ECRH}/P_{ECRH}=54.5 GHz/~0.3 MW) of inward-shifted magnetic field configuration (R_{ax}≤0.949 m) where trapped particle confinement is expected to be good. Our analysis suggests that suprathermal helically trapped electrons created by 2nd harmonic ECRH play an important role in destabilizing bursting modes [5]. Subsequently, in 2008, an experiment was conducted in LHD to create substantial helically trapped fast electrons and to verify phenomena observed in CHS.

Figure 1 depicts 2nd harmonic resonance layer position for 77 GHz ECR wave in B_t/R_{ax} of 3.6 m/1.51 T. Because 77 GHz gyrotron is the most powerful, to create substantial helically trapped electrons, the resonance layer was chosen to be off-axis for 77 GHz ECR wave and the wave was injected toward the bottom of helical ripple well. At first, we have checked the parameter range where instabilities detectable by Mirnov coils appear. Figure 2 shows maximum stored energies W_p measured with a diamagnetic loop as a function of line-averaged n_e for 2nd harmonic ECRH plasmas in inward shifted configurations. In these shots, the plasmas were initiated and heated only by ECRH (84 GHz/0.35 MW, 82.7 GHz/0.19 MW, 77 GHz/0.62 MW). Figure 3 shows a typical magnetic spectrogram in the fairly low density ECRH plasma (n_e<1.0x10^{18} m^{-3}) at B_t/R_{ax} of 3.6 m/1.51 T. In a series of shots, x-ray having the energy up to ~300 keV was detected, suggesting that there exist fast electrons in the experimental condition mentioned above. It should be noted that the fluctuation frequency seen in Fig. 3 is much lower than that of TAE. A detailed analysis is in process to understand magnetic fluctuation observed in low n_e ECRH plasmas of LHD.

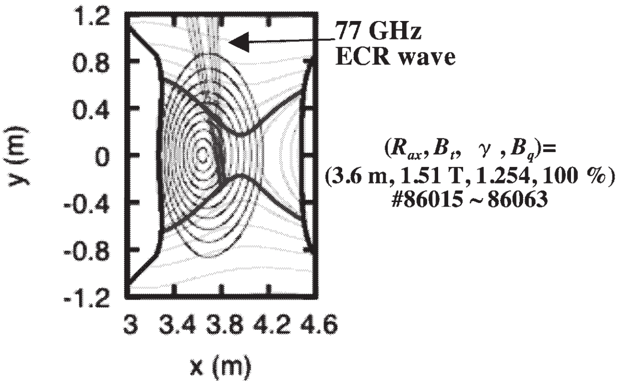

Fig. 1. 2nd harmonic resonance layer position for 77 GHz ECR wave.

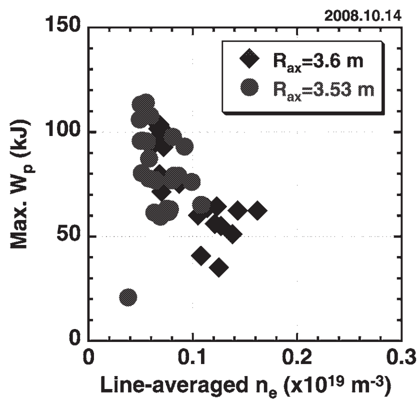

Fig. 2. Stored energy as a function of line-averaged electron density in 2nd harmonic ECRH plasmas.

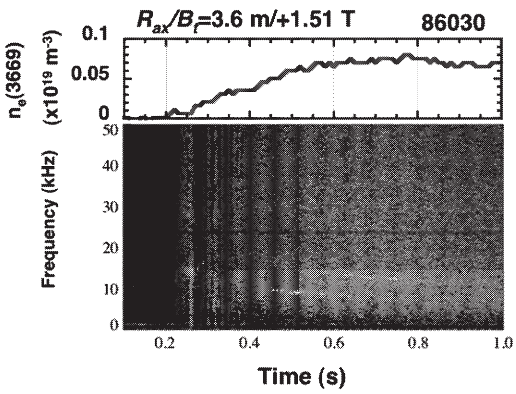

Fig. 3. Bursting and continuous magnetic fluctuation detected in a fairly low density 2nd harmonic ECRH plasma.

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3) Snipes, J.A. et al., Nucl. Fusion **48** (2008) 072001.
4) Chen, W. et al., Chin. Phys. Lett. **25** (2008) 3708.
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