§51. Observation of MHD Instabilities in an Acoustic Range of Frequency in LHD ECRH Plasmas with Suprathermal Electrons

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Magnetohydrodynamic (MHD) instabilities driven by beam ions and/or ICRH-produced suprathermal ion tail have been intensively studied in existing tokamak and helical plasmas because of a great concern about anomalous energetic-αs' transport due to α-driven MHD instabilities in future D-T reactor plasmas. Recently, several types of instabilities associated with suprathermal electrons, such as a fishbone mode, toroidicity-induced Alfvén eigenmode and beta-induced Alfvén eigenmode (BAE), have been recognized widely [1-8]. Note that compared with energetic ions in existing fusion experiments, SEs are characterized by small dimensionless orbit. Experiments with energetic ions and SEs are therefore complementary to each other in obtaining deeper, comprehensive understanding of excitation of MHD instabilities associated with energetic particles. In the Large Helical Device (LHD), coherent magnetic fluctuations have been regularly observed in an acoustic range of frequency in inward shifted, low-n_e ECRH plasmas (n_e~$1x10^{18}$ m^{-3}) when a substantial amount of suprathermal electron is present. Generally, the mode frequency tends to decrease as n_e increases when the ECRH power, P_{ECRH} is constant. At this point of time, it is hard to refer to whether the observed mode is classified into Alfvénic or acoustic-type mode. Note that the Mirnov fluctuation amplitude decreases as the density increases as seen in Fig. 1. Subsequently performed P_{ECRH} on/off modulation experiments clearly show that the mode frequency varies according to P_{ECRH} turn-on/off, i.e. it increases after the ECRH turn-on whereas it decreases following the ECRH turn-off as can be seen in Fig. 2. It should be noted that the electron density was almost constant during the P_{ECRH} modulation. This observation suggests that the mode frequency is associated with the plasma temperature. It also tells us that the instabilities observed in ECRH plasmas of LHD have an acoustic nature rather than Alfvénic. Note that the instabilities have finite toroidal mode number n of 2 and are not therefore classified into so-called geodesic acoustic mode (GAM). A possible candidate to explain the observation mentioned above is BAE of which frequency is expressed by a function of plasma temperature. Occasionally, the instability has shown recurrently bursting behavior in an extremely low-n_e discharge (n_e<$1x10^{18}$ m^{-3}) when on-axis heating is performed in addition to off-axis heating. In such a discharge, correlated with each MHD burst, the heavy ion beam probe diagnostic shows pulse-like positive increase of plasma potential at the core region, suggesting expulsion of suprathermal electrons from the core region.

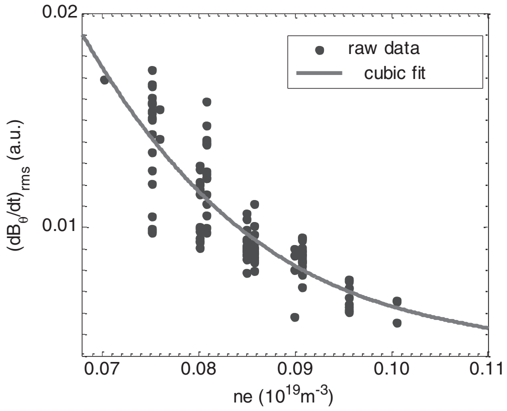

Fig. 1. Magnetic fluctuation amplitude observed in 2nd harmonic ECRH plasmas of LHD as a function of electron density.

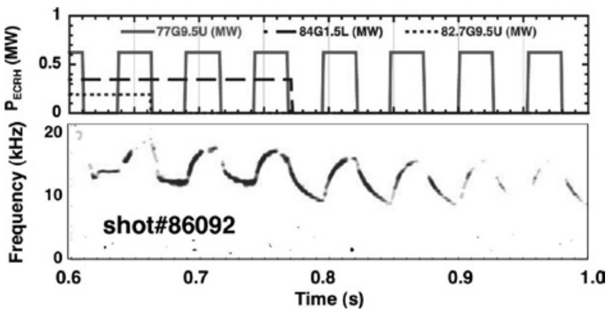

Fig. 2. Coherent magnetic fluctuations measured with a Mirnov coil in 2nd harmonic ECRH plasmas of LHD at R_{ax}/B_t of 3.53 m/1.52 T. Good confinement of deeply trapped electrons is expected in this magnetic configuration.

1) Wong, K.L. et al.: Phys. Rev. Lett. **85** (2000) 996.
2) Valovič, M. et al.: Nuclear Fusion **40** (2000) 1569.
3) Ding, X.T. et al.: Nuclear Fusion **42** (2002) 491.
4) Snipes, J.A. et al.: Nuclear Fusion **48** (2008) 072001.
5) Deng, C.B. et al.: Phys. Rev. Lett. **103** (2009) 025003.
6) Macor, A. et al.: Phys. Rev. Lett. **102** (2009) 155005.
7) Chen, W. et al.: Phys. Rev. Lett. **105** (2010) 185004.
8) Isobe, M. et al.: Nuclear Fusion **50** (2010) 084007.