§16. Proposal on Experiments of MHD Instabilities Driven by Supra-thermal Electrons in ECRH Experiment of Heliotron J

Isobe, M., Okamura, S., Yoshimura, Y., Toi, K., Kobayashi, S., Sano, F. (Kyoto Univ.)

The Heliotron J is one of advanced helical devices, realizing quasi-ominigeneous (QO) property in the magnetic field configuration on the Boozer coordinates. In a Heliotron J type configuration, the non-axisymmetric bumpy ripples play an important role in the viewpoint of neoclassical confinement [1]. In order to investigate the effect of bumpy ripples on confinement characteristics in $1/\nu$ regime, electron cyclotron resonance heating (ECRH) is an important key method. Currently, ECRH/ECCD experiment is being intensively carried out in Heliotron J [2]. It should be pointed out that if an appreciable amount of supra-thermal electrons are created in Heliotron J plasmas, energetic-particle-driven instabilities such as the energetic-particle continuum mode (EPM) and Alfvén eigenmodes may be destabilized. After the fishbone mode, which is now classified into EPM, excited by supra-thermal electrons produced by 2nd harmonic ECRH was first found in the DIII-D [3] and Compass-D [4], FB modes associated with supra-thermal electrons have been observed in several tokamaks [5,6]. In existing toroidal devices, experiments concerned with this subject have been so far performed by use of beam ions, perpendicular fast ion produced by ICRH and alphas born from D-T reactions. It should be pointed out that compared with alphas in ITER, in existing experiments, those ions mentioned above are fairly energetic, having much higher ratio of Larmor radius to minor radius and also showing significant shift of banana orbits from flux surfaces. Supra-thermal electrons are also capable of destabilizing those modes since excitation of those modes depends on precessional drift frequency of particle, not on mass [7]. They are characterized by small dimensionless orbit, similarly to alphas in reactor-relevant plasmas. In this point of view, it could be mentioned that instabilities driven by supra-thermal electrons are relevant to alpha particle driven modes in burning plasmas. As for helical plasmas, global Alfvén eigenmodes (GAEs) were excited due to supra-thermal electrons in the weak magnetic shear stellarator HSX with 2nd harmonic ECRH [8]. Because HSX is similar to Heliotron J in the viewpoint of weak magnetic shear, supra-thermal electron driven GAEs can be potentially excited due to supra-thermal electrons. Also in CHS, which has a similar plasma size compared with Heliotron J but strong magnetic shear, bursting recurrent EPMs were excited due to helically trapped supra-thermal electrons created by 2nd harmonic ECRH/ECCD. Figure 1 shows an example of MHD instabilities observed in CHS when ECCD was carried out [9]. It is noted that a neutral beam was not injected in this shot. When the net plasma current I_p induced by ECCD reaches a certain value, strong bursting MHD activities accompanied by fairly rapid frequency downshift appear. Hα light emissivity increases as the fluctuation amplitude increases. Correlated with MHD bursts, periodic increases of Hα emissivity are observed, suggesting expulsion of supra-thermal electrons. In order to explore the mode excitation mechanism, experiments by use of supra-thermal electrons is worthwhile and we propose experiments on MHD instabilities driven by supra-thermal electrons in Heliotron J.

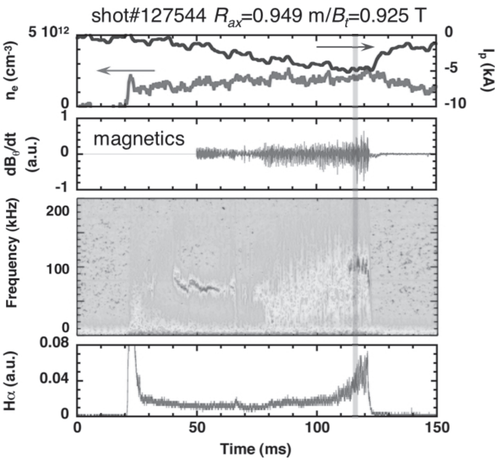

Figure 1 MHD Instabilities in an ECCD shot without neutral beam injection in CHS.

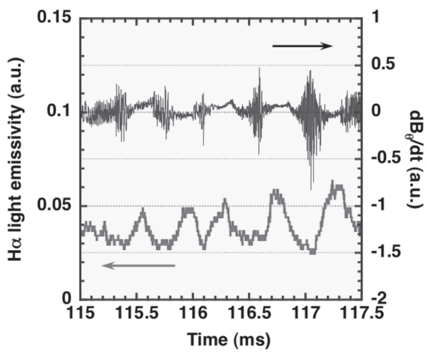

Figure 2 Time traces of Ha light emissivity and Mirnov coil signal while bursting EPMs are excited.

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