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Interaction between radial magnetic perturbation fields and fast electrons in LATE plasmas

LATEプラズマにおける径方向摂動磁場と高速電子の相互作用

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Effects of externally applied radial magnetic perturbations (MPs) on fast and bulk electrons have been investigated on the Low Aspect ratio Torus Experiment (LATE) device. When a small MP ($\delta b_{r(R=25cm)}/B_0 \sim 3.6\times10^{-4}$) is applied to plasma discharges with $B_v \geq 55$Gauss, reduction of the perpendicular pressure due to the high energy components and increment of the parallel one is estimated by magnetic analysis. In fact, the plasma current is increased during the application of MP. At the same time, the confinement improvement of the bulk plasma is also observed. However, the confinement improvement is not always observed depending on several mode patterns of MPs. In this presentation, we will show effects on MP fields produced by several MP coils in LATE plasmas.

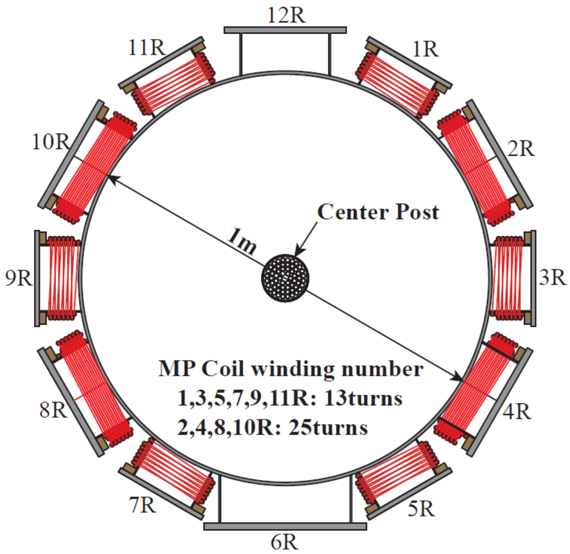

Fig.1. MP coils in the LATE device

In toroidally confined fusion plasmas, transport of particle and energy caused by externally applied magnetic perturbation field (MP) fields and/or therefore stochastic fields is very important for controlling the plasma performance and MHD instabilities. For example, losses of runaway electrons (can reach high energies of several tens of megaelectronvolts) in ergodized plasmas with resonant magnetic perturbations (RMPs) are investigated in JFT-2M [1] and TEXTOR [2]. Loss of high energy electrons is smaller than that of thermal electrons, because the large shift of the drift surface of high energy electrons from the magnetic surface causes a significant reduction in transport with RMPs.

In the Low Aspect ratio Torus Experiment (LATE) device, MP coils have been installed for transport and control studies of bulk and fast electrons produced by electron cyclotron heating and current drive (Fig. 1). The MP coils are constituted by ten sets. Each one is wound around a horizontal port section outside the vacuum vessel generating a radial MP field.

Figure 2 shows a plasma discharge waveform with the MP field produced by MP coils on the 4R and 10R port sections. An significant modification is observed with increases in Ip and n_eL as follows: Ip = 6.97kA → 7.73kA and $n_eL(R = 0.27\text{m}) = 0.74\times10^{17}\text{m}^{-2} \rightarrow 1.15\times10^{17}\text{m}^{-2}$ (Figs. 2(b) and 2(c)). Moreover, according to a visible spectroscopy measurement, the bulk electron temperature also increases, because the impurity line radiation of OV (excitation energy = 72eV) and CV (304eV) having high excitation energies is significantly enhanced compared with that without the MP phase.

Figures 3(a)-3(c) show the radial profiles of plasma pressures mainly due to the high energy components which is estimated by the magnetic analysis method using data from seventeen flux loops [3]. Here, $P_{\parallel}$ and $P_{\perp}$ indicate the pressures of parallel and perpendicular components to the toroidal magnetic field, respectively. The $P_{\parallel}$ profile on plasma core region increases in the applied MP

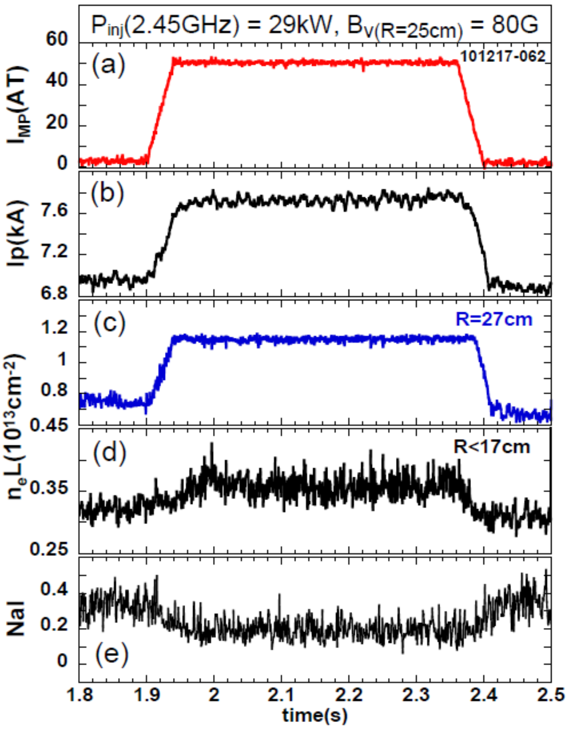

Fig.2. Time traces of the ECH/ECCD plasma with the MP field (I_{MP} = 50AT), where B_t = 480G, $B_{\mathrm{v(R=25cm)}}$ = 80G and P_{inj} = 29kW. (a) MP coil current (the total current is given in terms of the current in one coil winding times the number of turns). (b) plasma current. (c) and (d) line-averaged electron density at R = 27cm and R < 17cm, respectively. (e) Hard X-ray emission measured by a NaI scintillator having a line of sight at the center post.

phase, although the $P_\perp$ profile outside the last closed flux surface (LCFS) on the low filed side is clearly reduced. In addition, as shown in Fig. 2(e), reduction of the hard X-ray (HX) emission measured by a NaI scintillator which mainly results from fast electrons hitting the center post component is observed. Moreover, HX energy spectra measured by the vertical pulse height analysis system indicate reduction of the photon count in the high energy range. These results suggest that the applied MP field leads to the enhanced loss of the trapped electrons rather than the passing electrons. Furthermore, expanding of the LCFS is estimated by the calculation. As a consequence, the MP field have a positive effects on ECH/ECCD plasmas under the high B_{v} configuration, i.e. increase in Ip and improvement of the bulk plasma performance.

However, the confinement improvement is not always observed depending on several mode patterns of MPs. In this presentation, we will show effects on MPs produced by several MP coils shown in Fig.1. In addition to that, observation

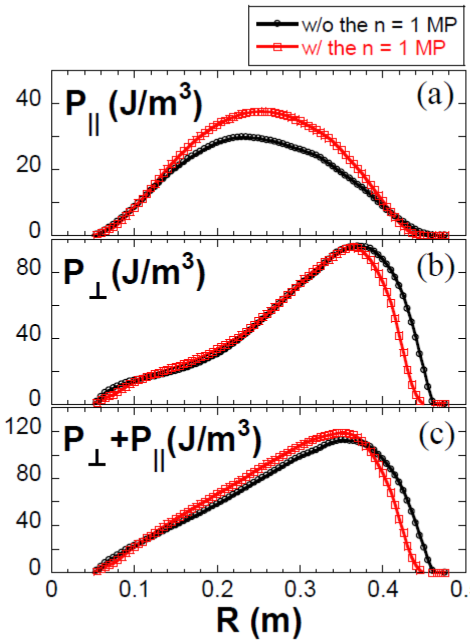

Fig.3. Radial pressure profiles estimated by a magnetic analysis method with and without the applied MP field on the horizontal cross-section. (a) parallel pressure, (b) perpendicular pressure and (c) sum of the pressures for the discharge as in Fig.2 (t = 1.86s and 2.33s).

results by using additional AXUV detector array and magnetic probe array recently installed in the LATE device will be also presented.

References

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