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Measurement time evolution of electron temperature and density profile for ECH plasma using Nd:YAG Thomson scattering system in Heliotron J

ヘリオトロンJにおけるNd:YAGトムソン散乱装置を用いたECHプラズマの電子温度・密度分布の時間発展計測

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Possibility of the internal transport barrier formation is investigated by T_e plofile of ECH plasma in lower density using a Nd:YAG Thomson scattering system in Heliotron J. To investigate the ECH power dependence on the electron temperature profile. The absoved ECH power depends on the power ratio of the X-mode in the injected EC waves,which can be changed by a polarizer. As a result, the steep electron temperature gradient formation is observed and the formation depends on the absorbed ECH power. These results suggest that the possibility of the barrier formation.

1. Introduction

Investigation of electron temperature and density profiles is one of the key issues to understand and improve the transport in magnetically confined plasma.

Especially, the electron internal transport barrier (ITB) formation, which plays an important role in plasma confinement, is related to the shape plasma spatial profile. The ITB formation was observed in electron cyclotron heating (ECH) plasmas in helical devices such as CHS [1] and LHD [2], and the formation has a threshold both in electron density and in the absorbed power to the plasma. In CHS, the electron temperature increased up to ~3 keV in the plasma core, and a large temperature gradient was observed at the barrier point. For the moment however, we have not observed a clear on Heliotron J yet. Presumably due to the require of lower electron density and the power from ITB, then the amount of scattered light that is detected with the conventional single-pulse Rb-laser Thomson scattering measurement was too low to determine the precise plasma shape.

In this paper, we investigated the barrier formation in lower density ECH plasmas in Heliotron J. A new Nd:YAG Thomson scattering system has been developed to measure time evolution of the electron temperature and density profiles with high spatial and temporal resolution [3]. Using the new Thomson system, the scattered light is increased by accumulation of the detected signals with multiple laser injection to the steady ECH plasma.

2. Experimental set-up

Heliotron J is a medium sized helical-axis heliotron device. The magnetic configuration is generated by a single helical coil with the pitch of L = 1/M = 4, two types of toroidal field coils and three pairs of vertical coils.

The YAG Thomson scattering system consists of two Nd:YAG lasers, each of which has pulse energy of 550 mJ, repetition frequency of 50 Hz, and pulse width of 10 ns, and 25 interference polychromators, corresponding to the 25 scattering volumes about 1 cm radial separation along the laser path. The measureable electron temperature ranges 10 eV -10 keV, and the electron density is greater than 0.5×10^{19} m^{-3}.

3. Profile shape of ECH plasma with Nd:YAG Thomson scattering measurement

Current-free plasmas were produced and heated by second harmonic ECH of 70 GHz and 331 kW in Heliotron J. In the experiments reported here, we measured n_e and T_e profiles in the standard configuration. The typical line-averaged electron density was $0.8\ \times10^{19}$ m^{-3}. The power ratio of X-mode component in the injected EC waves can be changed by a polarizerangle. Figure 1 (a) shows the electron temperature profile of ECH plasma

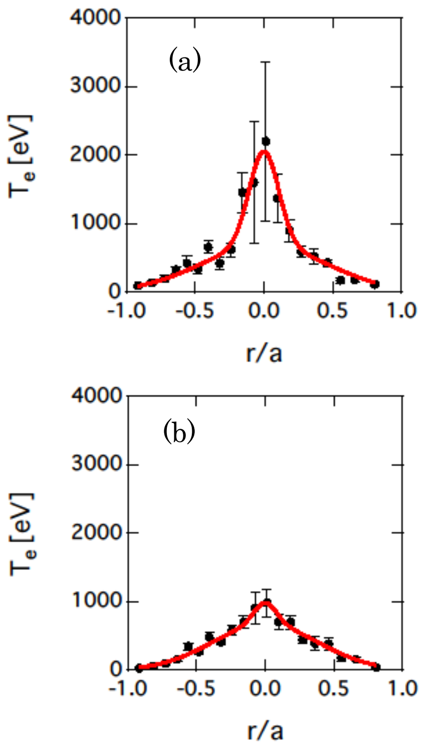

Fig.1. Electron temperature profile. (a) The polarization direction with high proportion of X-mode. (b) The polarization direction with low proportion of X－mode.

when the absorbed power is relating higher due to the higher X-mode fraction of 78%. To increase the scattered light of the Nd:YAG Thomson scattering measurement, the signals of 190 ms, 200 ms, 210 ms and 220 ms were accumulated. The central electron temperature increases up to ~2 keV and the profile shape is peaked. Due to the steep temperature gradient at (r/a<0.3), dome structure is formed in the core region On the other hand, as shown in Fig. 1(b), the electron temperature profile for the lower X-mode fraction of 31% is kept in lower central electron temperature of 1 keV. Note that the increase of the electron temperature is limited in the core region, and in the peripheral region (r/a>0.3), both plasma exhibit almost the same temperature profile.

Figure 2 shows the electron temperatures at the plasma center (r/a = 0) and the peripheral positon(r/a = 0.4) as a function of polarizer rotation angle. The X-mode power fraction as a function of the polarizer angle is also shown. When the absorbed power was higher due to the higher X-mode power fraction, the central electron temperature increased up to about 3keV for the polarization angles of 60 and 140 degree, while the temperature in the peripheral region is almost same (~500eV). Consequently, the steep electron temperature gradient was thus formed in the higher absorbed power. It is noted that the steep temperature gradient is not always formed in the higher absorbed power. This observation shows that the phenomena depend on the other plasma parameter, such as the electron density and the amount of impurity [1,2].

In conclusion, the formation of the steep electron temperature gradient and the power dependence suggest that the possibility of the barrier formation on Heliotron J. However, more detailed study, such as the fluctuation measurement, the electric field measurement may help understanding the theoretical bases of the barrier formation.

4. Summary

The possibility of the ITB formation was investigated using the newly developed Nd:YAG Thomson system on Heliotron J. The steep electron temperature gradient formation was observed in the lower electron density plasma. The formation depends on the absorbed ECH power. These results suggest that the possibility of the barrier formation. However the further transport study is required to understand the physics of the phenomena.

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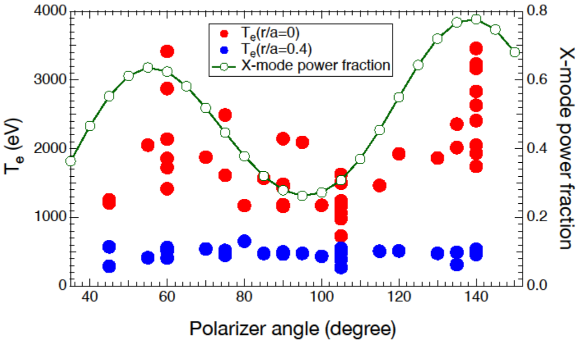

Fig.2. X-mode power traction and the electron temperatures of polarizer rotation angle as a function at the core, (r/a = 0), a peripheral region(r/a = 4).

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