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Measurement of Electron Heating by Magnetic Reconnection in the UTST Device

UTST装置における磁気リコネクション時の電子加熱現象の検証

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Formation of high-beta spherical tokamaks (STs) are investigated in the UTST device which have all of the magnetic coils located outside the vacuum vessel. When two STs are merged together to form a single ST, poloidal magnetic energy of the initial STs is converted to plasma thermal energy through magnetic reconnection. A Thomson scattering measurement system has been developed to conduct quantitative evaluation of the reconnection heating and high-beta equilibrium of the STs formed by plasma merging method.

1. Introduction

Ballooning mode is one of the most serious instabilities which limit the beta value of tokamak plasmas. The second stability region of the ballooning mode is attractive since it allows large pressure gradient to provide a high-beta equilibrium, however, transition from first to second stability region through narrow window requires difficult profile controls of pressure and plasma current. The plasma merging method has demonstrated the formation of high-beta ST by high-power heating provided by magnetic reconnection [1,2]. The purpose of this research is to investigate the electron heating mechanism in the magnetic reconnection event by using newly developed Thomson scattering measurement system.

2. Experimental Setup

The UTST device (see fig.1) forms a high-beta ST by double null merging (DNM) method shown in fig.2 [3].

①The currents of the equilibrium field (EF) and toroidal field (TF) coils make static spiral magnetic field inside the device. Hydrogen gas puffed in the device is ionized by the two washer guns located at the bottom and middle of the device.

②The current of the poloidal field (PF) coil makes two null points on which there are only toroidal magnetic and electric fields. Toroidal electric discharge is initiated on these points.

③When the current of the PF coil changes its sign, two STs are formed at the upper and lower sides.

④Since the directions of the PF coil current and two STs become contrary, two STs are pushed toward the mid-plane and merged to form a single high-beta ST.

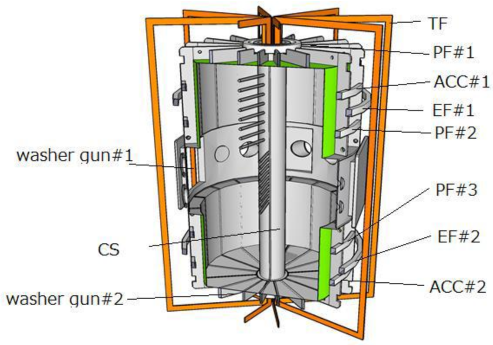

Fig.1 Schematic view of the UTST device.

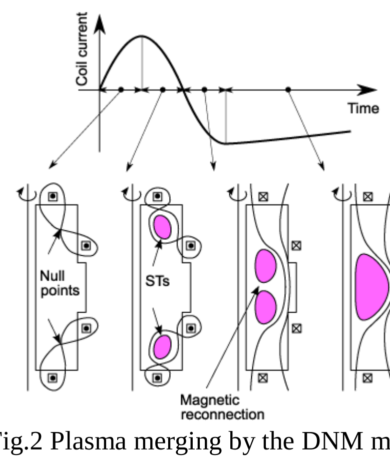

Fig.2 Plasma merging by the DNM method.

3. Two-dimensional Thomson Scattering Measurement System

Thomson scattering (TS) measurement is one of the most reliable diagnostics to measure the electron temperature of fusion plasma. The scattered light is collected by collection lenses with diameter of 150 mm and introduced to filter polychromators to analyze the spectrum. The width of the spectrum depends on the electron temperature. Since the power of the TS light is very small, we have to verify the possibility of the electron temperature measurement beforehand. We estimated the output voltage of the detectors E [V] in the polychromator from the power of the YAG laser P [W], the electron density n_e [m^{-3}], the length of the scattering volume L [m], differential scattering cross section σ [m^2], the solid angle of the collection optics Ω [srd], transmissivity of the lenses and windows including the interference filter T, and the sensitivity of the detector K [V/W].

$$E[V] = P[W]n_e[m^{-3}]L[m]\sigma[m^2]\Omega[srd]TK[V/W] \quad (1)$$

The estimated voltages from the three polychromator are shown in Fig.4. Optical components including the YAG laser and the collecting lenses are located on a single stand, which is able to slide along the radial direction, so this system can measure two-dimensional electron temperature profile. The initial results by using the TS system will be presented in the poster.

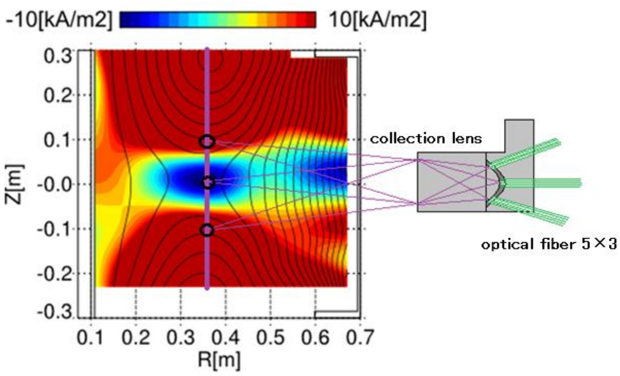

Fig.3 Thomson scattering measurement points superimposed on the experimental results of 2D magnetic measurement

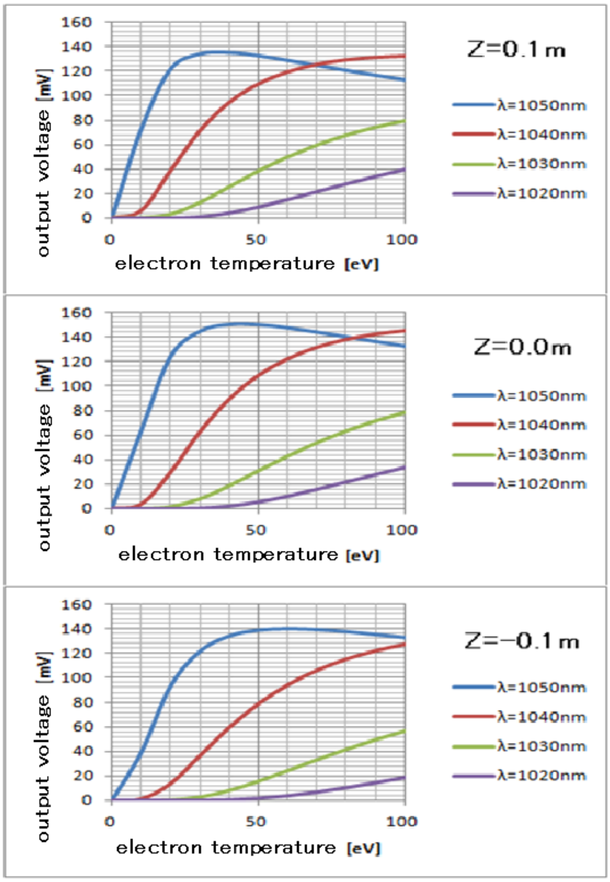

Fig.4 Estimated output voltages of detectors for three measurement positions.

Acknowledgments

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