19pE-5

Profile Characteristics of Fuelling Controlled Plasma using the Nd:YAG Laser 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粒子供給制御プラズマの分布特性

Naoki Kenmochi, Takashi Minami[1], Chihiro Takahashi[2], Shomei Tei, Shinji Kobayashi[1], Tohru Mizuuchi[1], Fumimichi Sano[1], *et al.*
釼持尚輝, 南貴司[1], 高橋千尋[1], 程崧明, 水内亨[1], 小林進二[1], 長崎百伸[1], 中村祐司, 岡田浩之[1], 門信一郎[1], 山本聡[1], 大島慎介[1], 木島滋[1], 臧臨閣, 大谷芳明, 木谷壮志, 桐本充晃, 洪重遠, 鈴木文子, 中山裕介, 西川幸佑, 原田伴誉, 村上弘一郎, 安枝樹生, 呂湘潯, 佐野史道[1]

Graduate School of Energy Science, Kyoto University
Gokasho, Uji, Kyoto 611-0011, Japan
〒611-0011　京都府宇治市五ケ庄　エネルギー理工学研究所附属センター北４号棟
Institute of Advanced Energy, Kyoto University[1]
Gokasho, Uji, Kyoto 611-0011, Japan
〒611-0011　京都府宇治市五ケ庄　エネルギー理工学研究所附属センター北４号棟

A new YAG-TS system has been developed to measure time evolution of T_e and n_e profiles in Heliotron J with high spatial and temporal resolution. A time evolution of electron temperature and density profiles was measured for the high-density neutral-beam-injection plasma with a high-intensity gas-puff (HIGP) fueling. The profiles reveal that not only large increases of core n_e but also increases of peripheral T_e contribute to the increase of the stored energy after the HIGP by increasing both the core and the peripheral pressures. It was found that HIGP could improve the global thermal confinement especially in the peripheral region.

1. Introduction

Spatial profiles measurement with time evolution of plasma density and temperature provides important information for the fusion plasma. The information is especially indispensable to understand the physics of plasma transport. In Heliotron J, spontaneous transition phenomena to an improved confinement mode have been observed [1]. Heliotron J also achieves high-density and high-performance plasmas with supersonic molecular beam injection [2] and high-intensity gas-puff (HIGP) fuelling [3, 4]. In this respect a high time and spatial resolution Nd:YAG laser Thomson scattering (YAG-TS) system for Heliotron J has been developed to measure the time evolution of electron temperature (T_e) and density (n_e) profiles [5-7]. The YAG-TS 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, a beam dump, and 25 interference polychromators, corresponding to the 25 scattering volumes about 1 cm radial separation along the laser path.

2. Time Evolution Measurement of T_e and n_e Profiles of Fuelling Controlled Plasma

We measured the time evolution of T_e and n_e profiles of high performance plasma with a HIGP, which was fuelled during 10 ms at a fuelling rate several times higher than that for the normal gas. The plasma is initiated by short-pulse electron cyclotron heating (ECH) and is sustained by neutral beam injection (co-NBI) with a port through power of 0.46 MW. Figure 1(a) shows the time evolution of the stored energy and the line-averaged density measured by both the microwave interferometer (curved red line) and the YAG-TS (brown circle) in the HIGP plasma. A rapid increase of n_e is observed and the stored energy starts rising after the increase of n_e in spite of no gas puffing. The line-averaged densities measured by the YAG-TS starts decreasing before the peak timing of the stored energy.

Figure 1(b) and 1(c) show the time traces of the core T_e(r/a = 0), the peripheral T_e(r/a = 0.6), the peaking factor of the T_e and the core n_e(0), the peripheral n_e(0.6), and the peaking factor of the n_e respectively. Figure 1(d) and (e) show the T_e and the n_e profiles for three characteristic timings, before the HIGP (t = 220 ms), just after the HIGP (t = 230 ms), and the peak timing of the stored energy (t = 250 ms). By the effect of the particle supply of the HIGP, the core n_e increases while the peripheral n_e holds, which makes the n_e profiles more peaking. The increase of the line-averaged density after the HIGP is dominated especially by the large increase of the core n_e. In terms of the temperature, the core T_e increases up to almost the same value as that before the HIGP. The peripheral T_e increases to the higher value than that before the HIGP. The difference of the change of the rate between the core and the peripheral T_e makes the T_e profiles flatter. As the results of both the increase of the core n_e and the large increase of the peripheral T_e, the pressure of whole region increases after the HIGP, which causes the increase of the stored energy. This result suggests that HIGP could improve the global thermal confinement especially in the peripheral.

3. Summary

We developed the YAG-TS system to measure the time evolution of T_e and n_e profiles in Heliotron J with high spatial and temporal resolution. With this system, we measured the time evolution of the profiles of the T_e and the n_e for the high-density plasma with the HIGP fueling. The time evolution of the T_e and the n_e profiles reveals that not only the large increase of the core n_e but also the increase of the peripheral T_e contribute to the increase of the stored energy after the HIGP by increasing both the core and the peripheral pressures.

Acknowledgments

This work was supported by the Collaboration Program of the Laboratory for Complex Energy Process, Institute of Advanced Energy, Kyoto University, and the NIFS Collaborative Research Program (NIFS10KUHK030, NIFS09KUHL, and NIFS10KUHL033).

References

[1] F. Sano *et al.*, Nucl. Fusion **45** (2005) 1557.

[2] T. Mizuuchi *et al.*, J. Nucl. Materials. **415** (2011) S443-S446.

[3] T. Mizuuchi *et al.*, IAEA-FEC2012, 8-13 Oct (2012), San Diego, USA, EX/P3-07

[4] S. Kobayashi *et al.*, in **40**th EPS (2013) P1-148.

[5] T. Minami *et al.*, Rev. Sci. Instrum. **81** (2010) 10D532.

[6] N. Kenmochi *et al.*, Plasma and Fusion Res. **8** (2013) 2402117.

[7] N. Kenmochi *et al.*, Rev. Sci. Instrum. **85** (2014) 11D819.

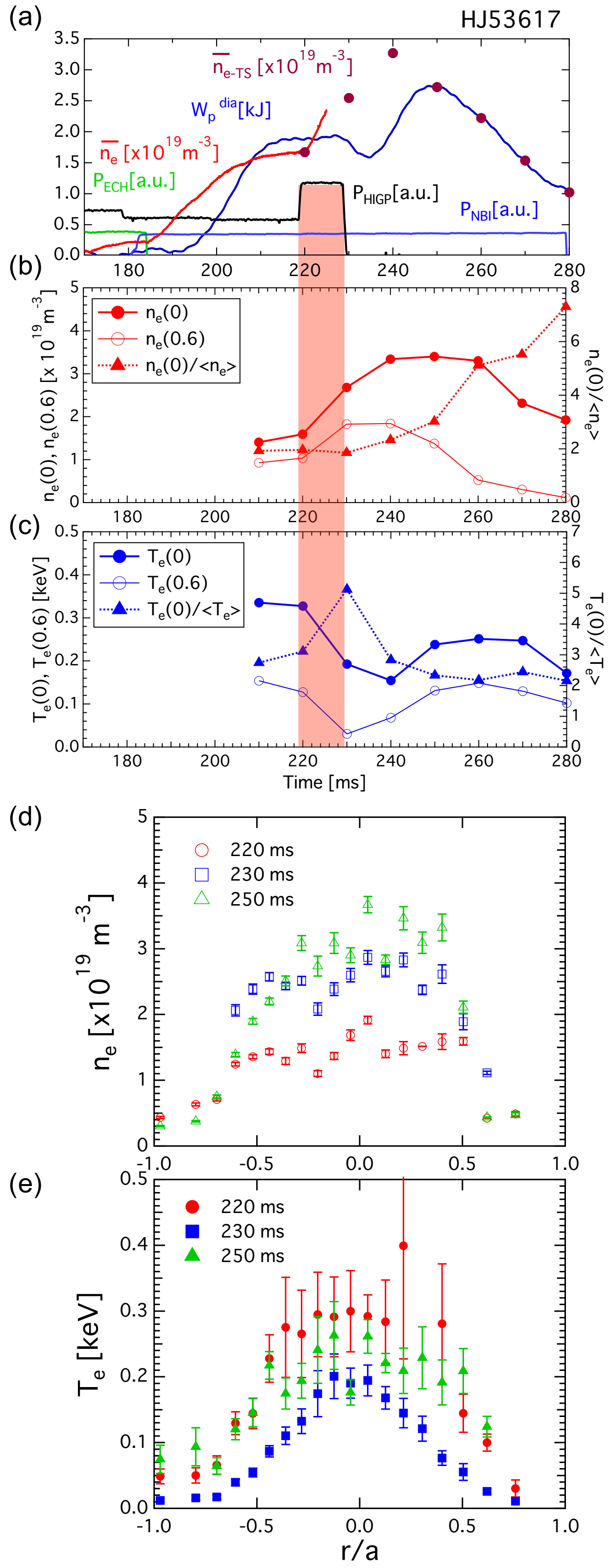

Fig.1. (a) Time traces of line-averaged density measured by interferometer and YAG-TS, stored energy in plasma, and timings of ECH, NBI, and HIGP. Time traces of (b) T_e(r/a=0), T_e(r/a=0.6), and the peaking factor of T_e and (c) n_e(r/a=0), n_e(r/a=0.6), and the peaking factor of n_e. Profiles of (d) T_e and (e) n_e for NBI-sustained plasma at 220, 230, and 250 ms.