19PA-028

Two-dimensional Spectroscopic Measurements on High-beta Dynamo Current Driven Torus Plasmas
ダイナモ電流駆動高βトーラスプラズマにおける2次元分光計測

T. Hanao[1], N. Oki[1], T. Kawai[1], Y. Uesaka[1], M. Nagata[1], Y. Kikuchi[1], N. Fukumoto[1], A.C. Hossack[2], B.S. Victor[2], B.A. Nelson[2], T.R. Jarboe[2]
花尾隆史[1], 沖伸晴[1], 川井貴弘[1], 上阪義晴[1], 永田正義[1], 菊池祐介[1], 福本直之[1], A.C. Hossack[2], B.S. Victor[2], B.A. Nelson[2], T.R. Jarboe[2]

Graduate school of engineering, University of Hyogo[1], University of Washington[2]
兵庫県立大学・院工[1], ワシントン大学[2]

The helicity injection was proposed as one of useful methods for start-up/sustainment of High-beta torus plasmas and during the helicity injection, the selective ion heating was observed on HIST. The multi-channel ion Doppler spectroscopic system (M-IDS) by high speed camera has been developed to measure time evolution of ion temperature and flow profile of High-beta torus plasmas. We have demonstrated two-dimensional spectroscopic measurement in toroidal cross section on HIST and HIT-SI3 (U. of Washington) by developed M-IDS system.

1. Introduction

The helicity injection had advanced to useful method for start-up/sustainment of high-beta torus plasmas and succeeded at start-up ST plasma current larger than 1 MA by coaxial helicity injection (CHI) [1] or at refluxing spheromaks by multi-pulsing CHI [2]. The plasma core region has observed selective ion heating due to viscous flow dumping after additional CHI [3] on HIST device [4]. The multi-channel ion Doppler spectroscopic (M-IDS) system by high speed camera has developed by cooperation from HIT-SI3 research team at University of Washington to measure ion temperature/flow profile diffusion after CHI.

In this work, our purposes are identification of usefulness of developed M-IDS system by two-dimensional spectroscopic measurement, observation of ion temperature/flow profile formation and diffusion with start-up/sustainment of high-beta torus plasmas by helicity injection and comparison with magnetic surface and current profile.

We will report to result of two-dimensional spectroscopic measurement from transient-CHI experiment on HIST and from inductive helicity injection experiment on HIT-SI3 device [5].

2. Multi-channel Ion Doppler Spectroscopic System

M-IDS system has developed that based on single IDS system detail shown in Ref. [6]. This system uses the 1 m spectroscope (Ritsu Ouyou Kougaku Co. Ltd.: MC-100N), optical fiber that has 8 channels branch (Mitsubishi Cable Industries: fiber core diameter = 0.4 mm, NA = 0.2) at the condensation part and high speed camera (Photron: FASTCAM SA4) at detector part. Figure 1 shows this system that set on HIST device. In this research, we measured toroidal cross section.

HIST device has Flux Conserver (FC) in this chamber, it needs to set original measurement port that has a window (diameter = 15 mm) to measure near the FC. And, each optical fiber fixed to measure special radius on each device.

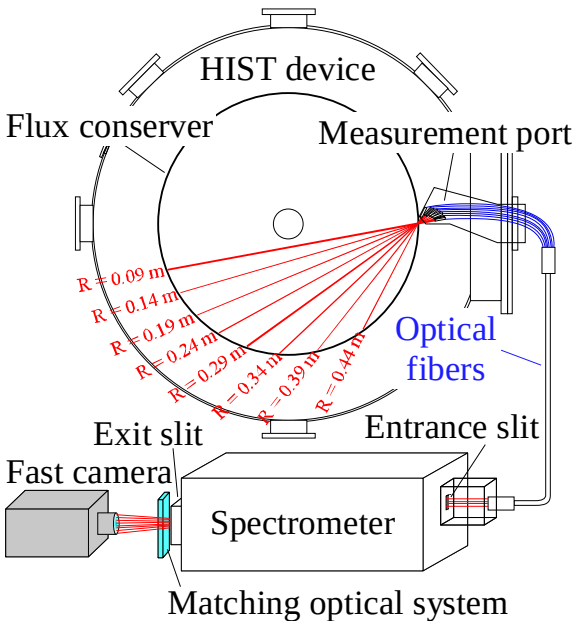

Fig.1 The multi-channel ion Doppler spectroscopic system setting on HIST device

The top of optical fiber has a plano-convex lens (Sigmakoki: diameter = 7 mm, f = 25 mm) to collects parallel light. Between each optical fiber, there is dummy fiber to decrease cross-talk. And, fiber bundle has adjusted entrance slit height and fiber bundle degree to get uniform light on each optical fiber.

The light from exit slit has widened to wavelength direction with column lens (Sigmskoki: 20 x 30 mm, f = 100 mm) and focused by high speed camera lens (Nikon: Ai Nikkor 105mm f/2.8S). Smaller figure size in high speed camera makes measurements with faster sample rate and lower stray light possible.

3. Performance Evaluation of M-IDS System

To evaluate M-IDS system performance, so sensitivity, S/N, resolution of wavelength and space are checked. Evaluation of M-IDS system used mercury lamp and set 60 fps sample rate at high speed camera.

Figure 2(a) shows 8 optical fibers output. In this figure, the transversal and the vertical axis indicates space and wavelength direction, respectively. The output data are saved in figure style and loaded by spreadsheet program (matlab). Loaded matlab data provide us instrument broadening and relative sensitivity by Gaussian fitting. This M-IDS system has large S/N because noise signal is small shown by figure 2(a).

The M-IDS system had input to only one channel to check the cross-talk that evaluated by output of space (each channel) direction (Figure 2(b)). There is no cross-talk because all channels except for input channel (4th channel) have only noise level output.

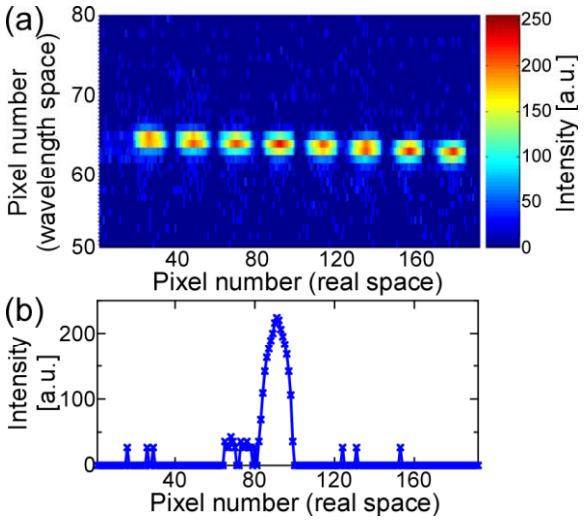

Fig.2 Evaluation of M-IDS system performance Output of optical fiber, (a) all channels and (b) 4th channel by mercury lamp.

The pixel spacing at M-IDS system was evaluated by changing 0.2 nm/s wavelength dial by drive unit. Calibrated pixel spacing and instrument broadening are about 0.019 nm/pixel and 0.044 nm, respectively (exchange to Carbon spectrum line temperature is 18.2 eV). These values are bigger than the single chord IDS system but are almost same as the M-IDS system at HIT-SI3. So we successfully constructed the M-IDS system using the high speed camera.

Acknowledgments

This work was supported by Japan / U. S. Cooperation in Fusion Research and Development (FP3-6).

References

[1] R. Raman *et al.*, Phys. Rev. Lett. **104** (2010) 095003.
[2] B. Hudson *et al.*, Phys. Plasmas **15** (2008) 056112.
[3] T. Hanao *et al.*, Plasma Fusion Res., **Vol.8** (2013) 1202104.
[4] M. Nagata *et al.*, Phys. Plasmas **10** (2003) 2932.
[5] B.S. Victor *et al.*, *54th APS DPP, Denver America*, (2013) GP8.00058.
[6] P. Gu *et al.*, Rev. Sci. Instrum. **75** (2004) 1337.