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Light intensity distribution measurement in TOKASTAR-2 plasma

TOKASTAR-2プラズマにおける発光分布測定

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Tokamak plasma and helical plasma position and shape are evaluated in TOKASTAR-2 by light intensity distribution using high-speed cameras in the tangential direction and in the radial direction. In tokamak experiment, the plasma center was located at the equatorial plane (Z = 0 cm) and the plasma disappeared in contact with the inner wall. In helical experiment, the plasma was stable below the equatorial plane when the RF resonance layer was located within the closed magnetic surface.

1. Introduction

TOKASTAR-2 device is designed and constructed to study tokamak-helical hybrid magnetic configuration (TOKASTAR configuration) [1]. This device is able to generate tokamak and helical configurations independently by using different types of coils. The main purpose of TOKASTAR-2 experiment is to evaluate the effect of helical field application on tokamak plasma and of the plasma current on compact stellarator configurations.

Figure 1 shows the coil system of TOKASTAR-2 device. This consists of six kinds of coil system; eight Toroidal Field (TF) coils, three-block Ohmic Heating (OH) coils, a pair of Pulsed Vertical Field (PVF) coils, a pair of static Vertical Field (VF) coils, two outboard Helical Field (HF) coils, and four Additional Helical Field (AHF) coils. VF coils are installed outside the vacuum vessel and the other coils are in it.

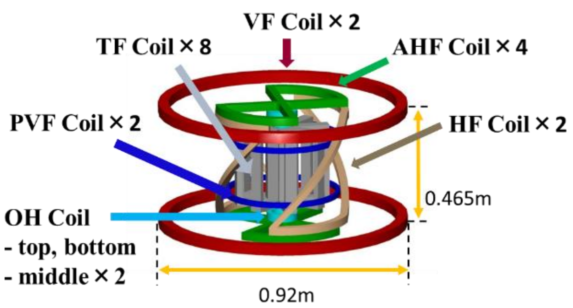

Fig.1. Coil system of TOKASTAR-2 device.

Capacitors are used in circuits for TF coils, OH coils and PVF coils, while DC power sources are used for VF coils, HF coils and AHF coils. The magnetic field strength in the plasma center is B_t ~0.1 T. The ECR heating (2.45GHz) is used for the pre-ionization and the injection power is ~1.4kW.

The plasma current and the duration of tokamak discharge were improved by adjusting the pulsed vertical field coil current [2]. Also, AHF coils were installed and measurement is made on helical plasma; helical field was applied using VF coils, HF coils and AHF coils in ECH plasma with the toroidal field [3-4].

2. Experiment setup and condition

In this study, the plasma position and shape are evaluated by the light intensity distribution of the high-speed camera image. The left side of Figure 2 shows the top view of camera sightlines in the tangential direction and in the radial direction. In the tangential direction the field of view is limited by the window flange and the outer legs of a TF coil. The right side of Fig.2 shows the side view of the field of view in the tangential direction.

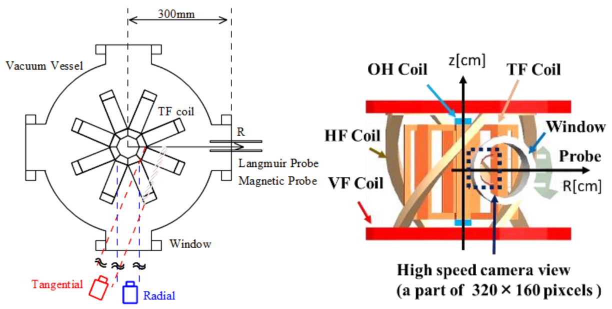

Fig.2. (Left) Top view of high speed camera sightlines. (Right) Side view in the tangential direction.

3. Tokamak plasma

After determining the optimal capacitor parameters, we adjusted the charging voltage of the capacitor of the PVF coils circuit (V_{PVF}). Figure 3 shows time evolution of PVF coil current and plasma current measured for V_{PVF} of 0.38 kV, 0.42 kV and 0.45kV. Figure 4 shows a part of the images taken tangentially by a high-speed camera at 60000FPS with 320×160 pixels per frame. When V_{PVF} was low (blue curves), double peaks were seen in the plasma current waveform because of lack of vertical field. On the other hand when V_{PVF} was high (green curves), plasma current reached 2.6 kA, but the discharge duration was short and the plasma current decreased sharply and tokamak plasma was crushed in contact with the inner wall (inner legs of TF coils) because of excess of vertical field. By adjusting V_{PVF}, tokamak plasma equilibrium control was improved, so the discharge duration was extended and the plasma current reached 2.2 kA (red curves). As shown in Fig. 4, the plasma center was located on the equatorial plane (Z = 0 cm) and the plasma disappeared with a gradual decreasing plasma current in contact with the inner wall.

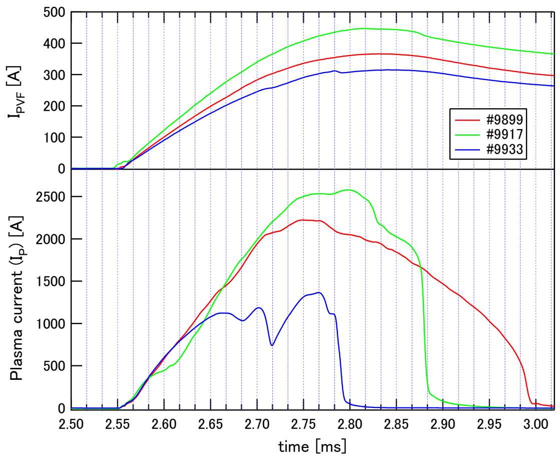

Fig.3. Comparison of measured PVF coil current and plasma current.

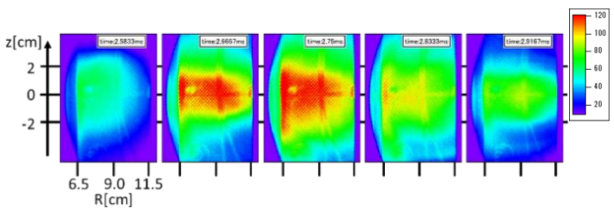

Fig.4. A part of high speed camera images in tokamak discharge, shot no. 9899.

4. ECH plasma with helical field applied

The currents in VF coils, HF coils and AHF coils were determined to make closed magnetic surface using magnetic field tracing code HSD [4-5]. For observing the effect of the helical field applied, we compared the images of the ECH plasma and helical plasma taken by a high-speed camera directed in the radial direction. The frame rate was set to 40000 FPS with 320×240 pixels per frame. Figure 5 shows the time evolution of light intensity of a pixel at Z = -4 cm. It was observed that the ECH plasma was oscillating. On the other hand helical plasma was stable below the equatorial plane. The light intensity was high during the period that RF resonance layer was located within the closed magnetic surface calculated with HSD, or I_{TF} was larger than 120 [A/turn], between the two vertical dotted lines.

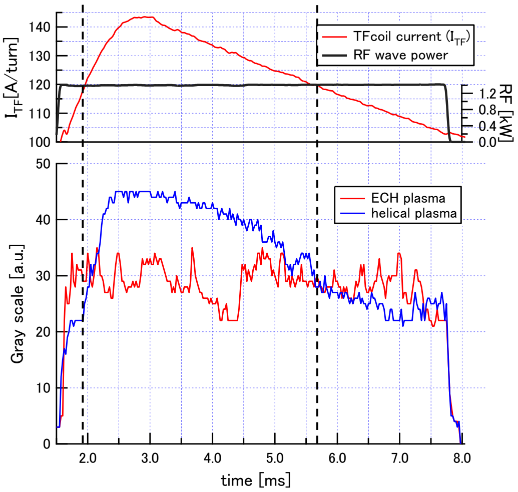

Fig.5. Signal of light intensity fluctuation of pixel at Z= -4 cm. I_{VF} = 0.10 kAT, I_{HF} = 2.55kAT, I_{AHF} = 2.875 kAT (DC power sources)

Acknowledgment

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