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Two-dimensional radiation profile measurements with AXUVD in LHD

LHDにおけるAXUVDを用いた二次元放射強度分布計測

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Two 20-channnel AXUV photodiode arrays are used to measure the radiated power distribution in LHD. From the one-dimensional radiation profiles measured with each array, two-dimensional radiation distributions are reconstructed using the tomographic technique, which can be mapped to any poloidal plane using the three-dimensional equilibrium database. To investigate the accuracy of the inversion, the radiation distributions during the super dense core (SDC) discharge with highly peaked density profile are compared with pressure profiles measured with the Thomson scattering system. In the discharges with additionally puffed neon or nitrogen, the enhanced radiation in the peripheral region is clearly observed.

1. Introduction

It is worthwhile to investigate the radiation property emitted from the hot plasma in the fusion experiment devices, since it determines the energy balance in the plasma. In addition, it is known that the radiated power distribution well reflects the impurity behavior which plays an important role in energy transport.

For the detection of the radiated power distribution in the plasma, the one-dimensional detector array has been utilized in many tokamaks which have the axisymmetric toroidal geometry. However, in helical systems like LHD without axisymmetry, the poloidal cross section varies toroidally and sometimes has a complicated shape. Therefore in order to identify the correct radiation distribution in the complicated three-dimensional plasma, it is necessary to observe radiation profiles from different directions with several detectors.

In LHD two detector arrays are utilized to reconstruct a two-dimensional radiation distribution on a cross section of the plasma column, using the computed tomography technique. For the tomography, two different methods are used and compared [1]. In the conference, observation results from the super dense core (SDC) discharge and the impurity injection discharge are presented.

2. AXUV photodiode array detector

In the bolometric measurements for high temperature plasmas, the absolute extreme ultraviolet photodiodes (AXUVD) are used for their high time resolution (~ 0.1 ms) and a flat spectrum variation of their photon efficiency from 200 eV up through the soft x-ray region [2].

For the tomographic reconstruction for the radiated power distribution on the cross section of the plasma column, two 20-channnel AXUVD arrays with pinhole are installed in the top and the horizontal ports, as shown in Fig. 1. In this configuration, the cross section is almost tangential to the toroidal direction, and the spatial resolution is about 5cm.

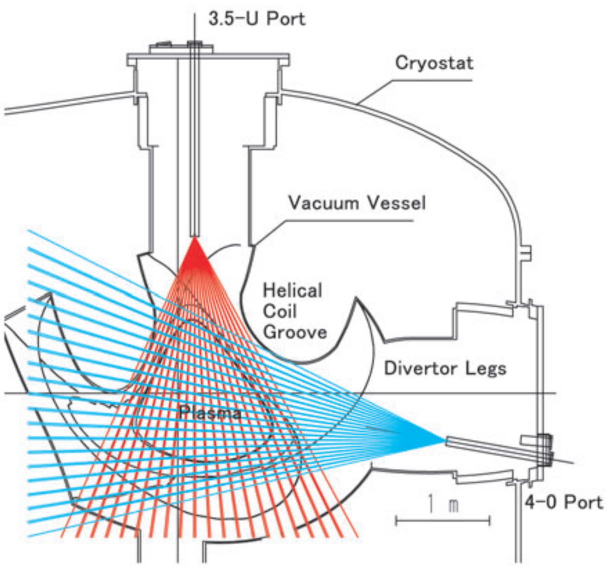

Fig. 1. Schematic view of observing geometry.

3. Tomographic method

To get the two-dimensional radiated power distribution image on the semi-tangential cross-section viewed with two AXUVD arrays, the plane is divided by 32 × 32 = 1023 pixels in the computed tomography. The Phillips-Thikhonov regularization method and the Hopfield neural network method are used in the procedure [3, 4].

4. Experimental results

4.1. *SDC discharge*

Recently the SDC mode was discovered in LHD, which is characterized by its high central electron density more than 5 x 10^{20} m^{-3}. In such a high density discharge, the relatively high radiation, i.e. bremsstrahlung radiation, takes place. The central position of this radiation generally corresponds to the plasma center where the plasma pressure is highest.

In this experiment, positions of the radiation peak observed with the AXUVD bolometer and the pressure peak observed with the Thomson scattering system are compared to confirm the accuracy of the alignment of detectors and the tomographic method. Fig. 2 shows the reconstructed radiation distribution measured with the AXUVD bolometer, superimposed with pressure profiles based on the Thomson scattering data and the three-dimensional equilibrium analyses. It is found that the plasma centers measured with the AXUVD bolometer and the Thomson scattering system agree well, although the shape of the radiation contour is relatively different from the pressure contour.

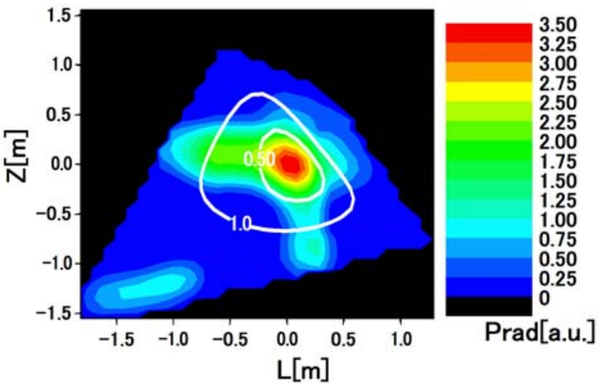

Fig. 2. Radiation distribution during SDC discharge measured with AXUVD bolometer. Pressure contour measured with Thomson scattering is also superimposed.

4.2. *Impurity injection discharge*

The impurity gas injection is tried to enhance the edge radiation and to cool the divertor plasma connecting to the divertor plates or wall materials. On the other hand, there exists a risk for the core plasma to be cooled, if impurities penetrate into the core region.

In order to see the behavior of the injected impurities, radiation distributions are compared between before and after the impurity gas injection, as shown in Fig. 3. It can be seen that the radiation from the core region is not so significant after the impurity injection, and the impurities stay in the edge region, which is a favorable situation.

(a)

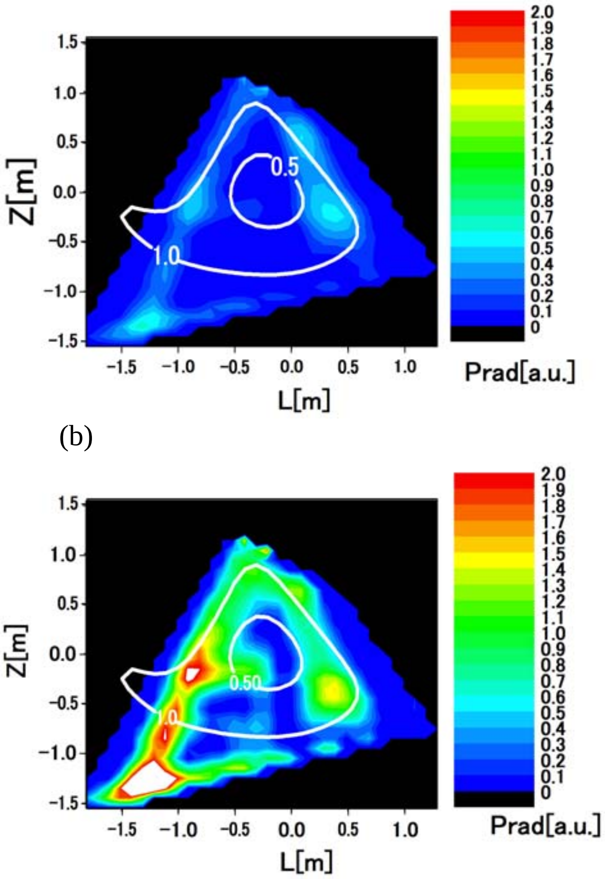

Fig. 3. Radiation distributions (a) before and (b) after impurity gas puffing.

References

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