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Estimation of three-dimensional emissivity distribution with multi-imaging technique

A. Sanpei[1], S. Inagaki[1], T. Inoue[1], T. Sasaki[1], Y. Ashida[1], H. Fujiwara[1], Y. Kawachi[1] and H. Himura[1]
[1] Department of Electronics, Kyoto Institute of Technology
e-mail (speaker): sanpei@kit.ac.jp

Three-dimensional (3D) information for plasma is important for a wide range of plasma research fields. Experiments and simulations have shown the importance of helically deformed configurations and 3D mode structures in high temperature plasmas [1]. In process plasmas, the non-uniform density of plasma would cause non-uniform deposition on the wafer. Among the various devices, separated two or more detectors with computed tomography are widely used to determine the 3D information. However, many experimental devices are faced with a limitation of the number of viewing ports and viewing areas. It is required that a method distinguishing 3D structure of plasma from a certain image obtained with small number of viewing ports. To obtain 3D structure of plasma from limited direction, we are developing two methods with multi-imaging techniques.

First, we have developed 3D imaging system [2] for low temperature plasma with integral photography [3] and 3D deconvolution techniques [4,5]. Developed system is conducted with multi lens and captures visible light emitted from plasma. The system has been applied a surface wave plasma. Reconstructed distribution suggests that plasma emission is localized around the powered antenna of microwave with hollow structure [6]. Estimated emission profile with double probe also suggests hollow structure.

Next, basis expansion technique has been applied to a torus plasma [7]. Developed system is conducted with multi-pinhole disk and micro channel plate. Projected intensity of soft X-ray is expressed as convolution between emissivity and projection matrix. We apply basis expansion with suitable orthogonal functions to emissivity. Then, projected image is also expressed as summation of basis patterns. In reconstruction from obtained image, we use the Lasso regressions. Developed system has been applied to RFP plasmas experimentally. The experiments have been conducted in low-aspect ratio torus RELAX [8,9]. Figure 2 shows reconstructed SXR emission profile from experimentally obtained multi-SXR image. The SXR emission profile with asymmetric peaks is obtained. It suggests that the high-temperature and/or high-density regions exist.

Detailed analysis and further applications will be discussed.

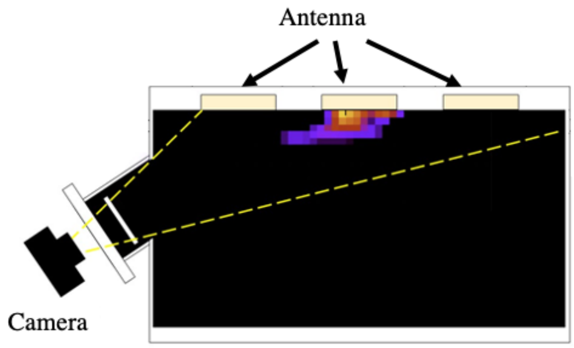

Fig.1 Obtained reconstructed light sources overwritten on the schematic of the chamber. A hollow structure is observed [6].

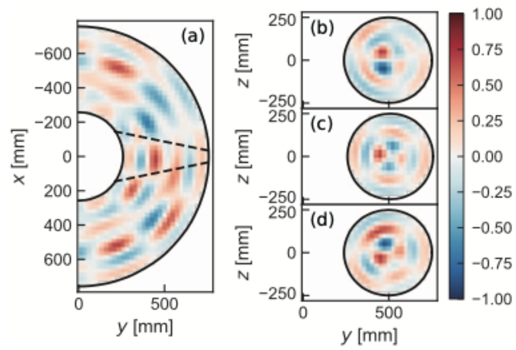

Fig.2 Cross-sectional views of the 3D emission profile of SXR calculated by using Lasso regressions. Black dashed lines indicate the boundary of the field of view from the camera [9].

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