Estimation of three-dimensional emissivity profile from one viewing port

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Three-dimensional (3D) information of plasma is important for a wide range of plasma research. For example, in toroidal fusion plasmas, recent progresses have shown the importance of helically deformed configurations and 3D tearing mode structures [1]. In dusty plasmas, 3D information of positions of fine particles in plasma is important for studying physics such as the investigation of transition processes in real crystal [2]. Among the various devices, separated two or more detectors with computed tomography are widely used to determine the 2D/3D information. However, many experimental devices are faced with a limitation of the number of viewing port and viewing area. It is required that a method distinguishing 3D structure of plasma from a certain image obtained from one viewing port.

The integral photography technique provides a 3D imaging capability by employing a lenslet array or multi-pinhole in order to capture scattered light rays from slightly different directions. The 3D reconstruction is performed computationally by generating inverse propagating rays within a virtual system similar to the recorded one. According to the procedures, 3D information is estimated from one picture obtained from one viewing port [3]. Applying the method to a system containing many point light sources, it tends to generate many ghost particles as a reconstruction result. Moreover, applying above method to translucent plasma, out of focus parts of the plasma structure at the front and rear of the plasma region obscure the sharp.

In this study, we have developed 3D imaging system for plasma with integral photography and 3D Lucy-Richardson deconvolution (LRD) techniques. Principle verification experiment is carried out in dusty plasma. The design of the imaging system for 3D reconstructions of dusty plasmas is constructed with a multi-convex lens array (6x9 or another) and a typical reflex CMOS camera [6]. The system has been applied to observations of fine particles floating in a horizontal, parallel-plate radio-frequency plasma. We identify the 3D positions of dust particles from a single-exposure image obtained from one viewing port with developed system [7].

As a next step, developed 3D imaging system has been applied surface wave plasma to obtain 3D emissivity distribution. In fig.1, reconstructed emissivity distribution is superimposed on a schematic of experimental configuration. Preliminary result suggests that plasma emission is localized around the powered antenna of microwave. Elongation or reconstructed emissivity along optical axis would be artifact due to LRD.

Moreover, a modified system with a high-speed camera has been applied in order to identify the emission structures associated with dominant magnetohydrodynamics instabilities in high temperature Reversed Field Pinch plasma. We can estimate rough distribution of emissivity with a certain image from one viewing port.

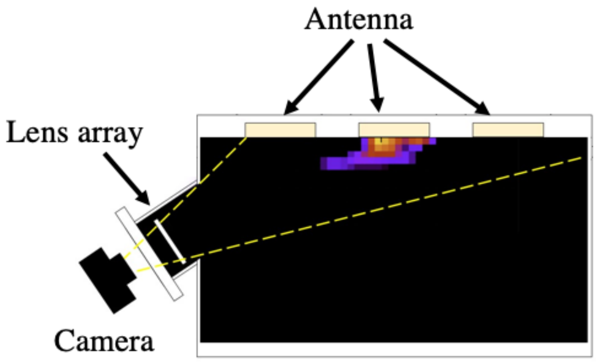

Figure 1. Example of reconstructed emissivity distribution.

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