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イメージングとトモグラフィを用いたプラズマ中の三次元構造計測

Measurements of 3-D Structure in Plasmas with Imaging and Tomography Technique

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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 [3]. 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.

Applying above method to a translucent object, like as plasma, reveals a fundamental problem. If the image is refocused to the center of a plasma region, out of focus parts of the plasma structure at the front and rear of the plasma region obscure the sharp, in focus plane synthetically refocused to at the center. One solution for the problem is the technique of 3D deconvolution. In this study, we develop a 3D imaging system for plasma with integral photography and the Lucy-Richardson deconvolution techniques [4,5].

Principle verification experiments are carried out in dusty plasma and reversed field pinch device RELAX [6]. The design of the imaging system for 3D reconstructions of dusty plasmas is constructed with a multi-convex lens array (6x9) and a typical reflex CMOS camera [7]. In fig.1, positions of test particles are compared with discrete light souses reconstructed from blur 3D light field. The value of *z* is distance from lens array along the optical axis. Reconstruction error is approximately 100μm. The system has been applied to observations of fine particles floating in a RF plasma. We identify the 3D positions of levitating dust particles from a single-exposure image obtained from one viewing port with developed system. Moreover, 3D distribution of visible light emissivity is estimated in RELAX with concave lens array (3x3) and a high-speed camera.

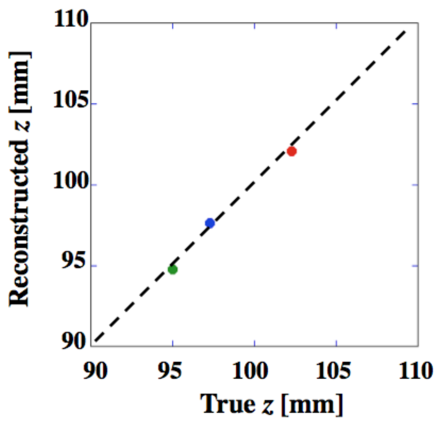

Figure1: Position of reconstructed light source is plotted as a function of true position.

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