Filtering Extraction: Simultaneous Measurement Technique for Three-dimensional Density and Velocity Distributions

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The study on the stable and/or unstable gas stratified flow is very important for the accidental analysis of the fusion reactors, e.g., Ingress of Coolant Event (ICE) and Loss of Vacume Accident (LOVA). When these accidents occur, the exchange flow caused by buoyance force may play an important role on the scenario of the accident. Therefore, the characteristics on the buoyancy flow should be invesigated. There are lots of studies on the buoyancy flow. However, there are few studies on the measurement of three-dimensional behavior of the buoyancy flow. It is very difficult to measure the transient three-dimensional flow field with buoyancy.

The 3D velocity distributions can be measured by the Holographic Particle Image Velocimetry (HPIV; Barnhart et al., 1994, Applied Optics, **33**). The HPIV is the technique to capture the particle movement on the Hologram.

While, using the Optical Tomography (OT) technique, the 3D density distributions can be measured (Merzkirch, 1974, Flow Visualization, Academic Press). Using the holographic interferometer, the information of the density can be recorded onto the hologram. In this study, the simultaneous measurement technique for three-dimensional density and three-dimensional velocity distributions was evaluated using the HPIV technique.

Originally the HPIV is technique to record only scatterring from particles. When there were density distributions in the interrogation region, the plane optical wave may be modulated because of the difference of the refraction indices. Then, both of the plane wave modulated by density and the spherical wave by particle scatter were interfered with the reference beam, being recorded on the single hologram (fig 1). With reconstructing the hologram, the both of the modulated plane wave and spherical wave were reconstructed. Since the plane wave and spherical wave belong to low and high spacial frequency, respectively, the plane wave was reconstructed with the optical low-pass filter, resulting in the information of the density distributions to be obtained as interferogram. With the optical high-pass filter, the particle three-dimensional positions were determined. With the interferogram images the three-dimensional density distributions were obtained i.e.,the same procedure with the OT technique. With the particle positions the three-dimensional

velocity distributions were obtained i.e., the same procedure with the original HPIV technique. The procedure of the low-pass and high-pass filtering is shown in Fig. 2. The two informations are separately reconstructed from the same hologram.

In order to investigate the feasibility of the proposed technique, the Helium-jet were recorded from only one direction. The information of the density and particle position were separately observed. Fig 2 shows the calculated Velocity ditributions at nozzle center. The upward jet flow were well observed. Fig 3 shows density distributions calculated by the Maximam Entropy method with the asuumption of two dimensional cylindrical coordinate. Both data were well explained the flow field showing the effectiveness of the proposed technique (Filtering Extraction: FX). The three-dimensional measurement will be the next step.

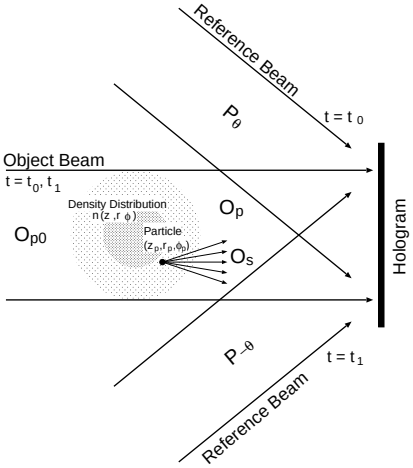

Fig. 1Hologram recording configuration in FX method

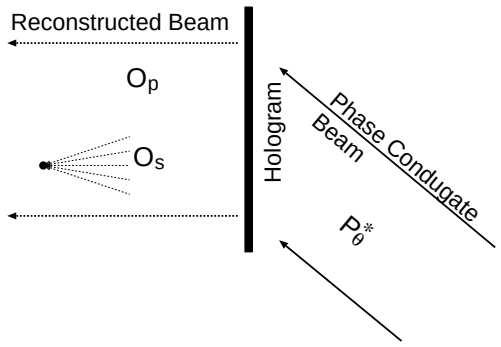

Fig. 2Hologram reconstruction in FX method

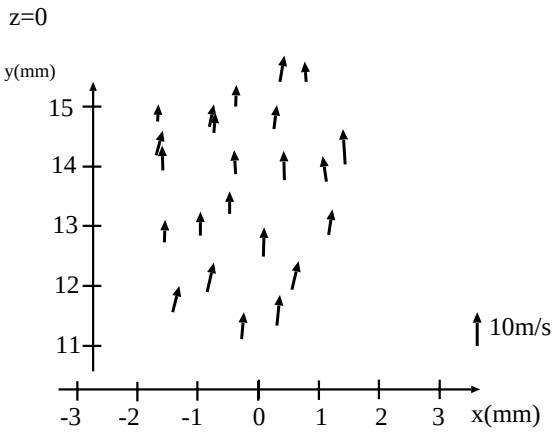

Fig. 3 Two-dimensional velocity distribution at nozzle center

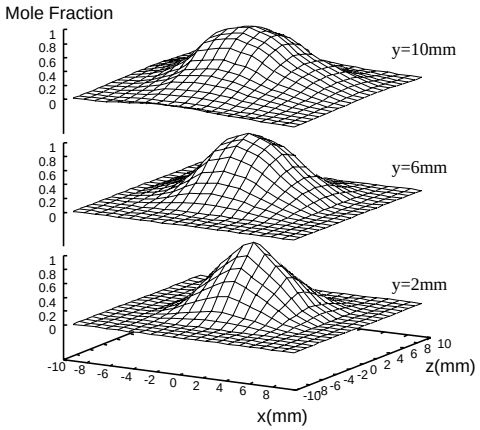

Fig. 4 Two-dimensional density distribution around nozzle exit