Instantaneous Three-Dimensional Density Measurements Using Tomographic Background-Oriented Schlieren

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ABSTRACT

Experimental density field measurements are critical in describing the dynamics of turbulent convective heat transfer and mixing. In turbulent flows, the density field is strongly three-dimensional and varies with time. Tomographic background-oriented schlieren (BOS) is an optical technique providing volumetric density measurements across a wide range of scales by utilising the Gladstone-Dale relation between a fluid's density and refractive index. In this work, a fifteen-camera tomographic background-oriented schlieren setup is used with a combined filtered back-projection and algebraic reconstruction technique (FBP-ART) tomographic reconstruction to quantify the density field of a turbulent heated jet. Cameras are used to simultaneously image reference background patterns while looking through the flow from multiple angles. Refractive index gradients in each camera's field of view produce apparent displacements of the background patterns, which can be related to the gradients. Tomographic reconstruction methods are employed to describe a three-dimensional three-component refractive index gradient field responsible for producing the observed displacements. The solution of a Poisson equation, based on the reconstructed gradients, is used to obtain the refractive index field itself and hence the instantaneous three-dimensional density fields. Experimental challenges in implementing tomographic BOS, such as spatial and temporal resolution, are discussed.