X-ray Visions of Multiphase Flow

Jin Wang

Argonne National Laboratory, USA, wangj@aps.anl.gov

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With brilliant synchrotron x-ray sources, microsecond time-resolved synchrotron x-ray radiography and tomography have been used to visualize the detailed three-dimensional structure and dynamics of high-pressure, high-speed multiphase fluid flows (Figure 1). The measurement allows quantitative determination of the mass distribution in optically impenetrable regions due to the multiple scattering of visible light by small atomized liquid droplets in and surrounding the flow. In the situation where extremely axial asymmetric flow are encountered, mass deconvolution and cross-sectional fluid mass distribution can be computed and reconstructed based on the monochromatic and time-resolved x-tomographic images collected from many rotational orientations of the flows.

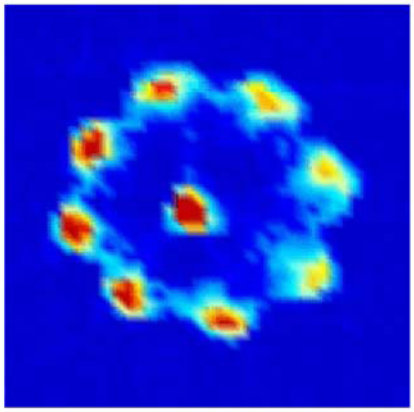

Fig. 1 Reconstructed spray cross-section at 0.8 mm from a multi-orifice gasoline direct injection nozzle exit. The color represents the fuel mass density or volume fraction.

Very recently, we developed x-ray phase-contrast imaging (Figure 2) to obtain single-shot images of the flows to study the liquid atomization behavior and hydrodynamics of liquid jet. In addition it is possible to develop particle imaging velocimetry measurements in the x-ray region for optically opaque flows. The x-ray diagnostics yield highly quantitative information on the mass and droplet distribution and dynamics of highly transient fluid flows.

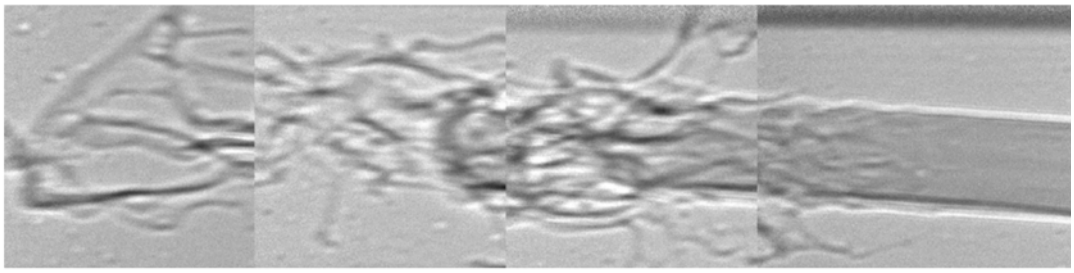

Fig. 2 Single-shot x-ray phase-contrast imaging of diesel spray injected at 400 bar of pressure at the beginning of the injection.