

Title: A review of recent developments in x-ray diagnostics for turbulent and optically dense rocket sprays

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Highly efficient mixing and atomization of fuel and oxidizers is an important factor in many propulsion and power generating applications. To better quantify breakup and mixing in atomizing sprays, several diagnostic techniques have been developed to collect droplet information and spray statistics. Several optical based techniques, such as Ballistic Imaging and SLIPI have previously demonstrated qualitative measurements in optically dense sprays, however these techniques have produced limited quantitative information in the near injector region. To complement to these advances, a recent wave of developments utilizing synchrotron based x-rays have been successful been implemented facilitating the collection of quantitative measurements in optically dense sprays.

In the following paper, a summary of experiments are discussed which were performed on a NASA designed pressure swirl atomizer and gas-liquid coaxial injector using both water and cryogenic fluids at the Advanced Photon Source (APS), Argonne National Lab. Measurements with high spatio-temporal accuracy, are demonstrated. Simultaneous measurements of radiography and fluorescence have demonstrated line-of-sight, time averaged measurements of total mass and phase distributions within cryogenic and water sprays. These techniques were extended with time-resolved radiography measurements which demonstrated the techniques ability to collect and non-invasively measure the evolution of turbulent spectra in multiphase flows. Complementing line of sight measurements, recent experiments using two-dimensional kHz rate x-ray 'white light' imaging have demonstrated the techniques ability to resolve previously hidden features in atomizing flows; such as hollow droplets and stable mixed phase states.