Ultra-fast Structured Laser Illumination Planar Imaging (SLIPI) for single-shot imaging of dense sprays

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Abstract

Recently, a novel imaging technique, called Structured Laser Illumination Planar Imaging (SLIPI), has demonstrated great potential for the suppression of the multiple light scattering in spray imaging. The method uses a laser sheet which is modulated in the spatial domain. Photons which are directly scattered keep the structural information of the laser sheet; whereas, the photons that have experienced several scattering events lose this information, resulting in a variable offset on the recorded image. Using a spatially modulated incident light thus enables the directly scattered photons to be distinguished from the multiple scattering intensity contribution. However, to homogeneously illuminate the spray, three images are required, where the modulation of the incident laser beam is successively shifted one third of a period vertically. By adequately post-processing the three images the multiple scattering contribution can be diminished. However, the time interval within which these images are recorded must be short enough to freeze the flow motion, making "single-shot" SLIPI of highly atomizing sprays particularly challenging. In this article, we present an ultra-fast SLIPI system with the capability of freezing flow motions up to ~600 m/s. The instrument was tested on a hollow-cone water spray, running at 50 bar injection pressure, and high resolution single-shot images, in which multiple scattering effects were efficiently suppressed, were obtained. Such images provides detailed information of complex dynamic flow behavior occurring in the dense spray region, e.g. primary and secondary break-ups. In addition, we demonstrate that the RMS extracted from such single-shot SLIPI images enables statistical investigations of the break-up process as well as a better estimation of the liquid sheet length.

Key words: Multiple scattering suppression, planar laser imaging, contrast enhancement, spray break-ups

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