Analysis of the SLIPI technique for multiple scattering suppression in planar imaging of fuel sprays

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Abstract

Structured **L**aser **I**llumination **P**lanar **I**maging (SLIPI) is a new laser sheet based diagnostic able to significantly increase the contrast of spray images by removing the multiple scattering noise contribution. The technique has been recently developed and applied to the study of a conventional hollow-cone water spray, where the transmission through the near-field spray was 26%. In such condition, it has been shown that 44% of the total optical signal, corresponding to multiply scattered photons, could be removed. In order to now employ the technique to more challenging sprays, such as air-blast atomizer and Diesel sprays, where the transmission can be reduced down to ~0.25%, further investigations and refinements of the approach are required. This article focuses on the analysis, optimization and application of SLIPI for fuel sprays by means of a modern 3-dimensional computational model. The simulation is performed via a validated Monte Carlo code in association with a ray-tracing approach, to simulate the propagation of the incident laser radiation through the spray and the collection optics respectively. This computational work aims to quantify the amount of multiple light scattering detected by both the conventional Mie laser sheet imaging and the SLIPI technique. Results are compared for two hollow-cone fuel sprays of different transmission and droplet size properties. In the first spray the laser transmission, at λ = 532 nm, is 5% in the dense region and 27% in the dilute region, with a droplet size distribution ranging from 8 to 68 μm. The second spray is assumed to be more highly atomized, with a transmission of only 0.17% in the dense region and 7.5% in the dilute region, and with a droplets size distribution ranging from 4 to 34 μm. From these numerical calculations, it is observed that the resultant SLIPI signal tends to be closer from the pure single scattering signal when reducing the spatial period of the incident modulated light. We demonstrate here that the technique should be able to suppress an unwanted light contribution up to 91%, of the light intensity detected in the conventional planar imaging.

Key words: Single scattering extraction, polydisperse fuel sprays, Monte Carlo simulation

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