Development of future spray imaging techniques using General Purpose GPU accelerated Monte Carlo simulation

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Abstract

The past decade has seen the development and application of emerging laser techniques for spray imaging. Two noticeable examples are Ballistic Imaging (BI) and Structured Laser Illumination Planar Imaging (SLIPI). The main motivation in developing such novel techniques was to filter out the blurring effects introduced by multiple light scattering in order to obtain reliable two-dimensional qualitative and quantitative spray information. In parallel to this experimental development, Monte Carlo (MC) simulation of light propagation and scattering through spray systems has also been initiated. While the MC simulation is a powerful and versatile tool for modeling various spray geometries and detection schemes on a single computer, its main drawback remains its long computational time. However, since 2007 a programming approach, named Compute Unified Device Architecture (CUDA), has been created for performing general purpose calculations on Graphics Processing Unit (GPU), as a data-parallel computing device. Thanks to the continuously increased number of cores in combination with larger memory bandwidth, recent GPUs offer considerable extended resources for general purpose computing. In this article, we describe an accelerated version of a validated MC model (originally presented at ICLASS-2006), for the simulation of laser light propagation in sprays. The code is now capable of running the calculations on a modern GPU card, showing a ~100x increase in simulation speed compared to the original version of the code. Thanks to these new possibilities, the MC model presented in this article allows detailed performance analysis of various laser imaging techniques. This is demonstrated for BI where a time-gating approach is used and for SLIPI where a modulation-based filtering is employed in the spatial domain.

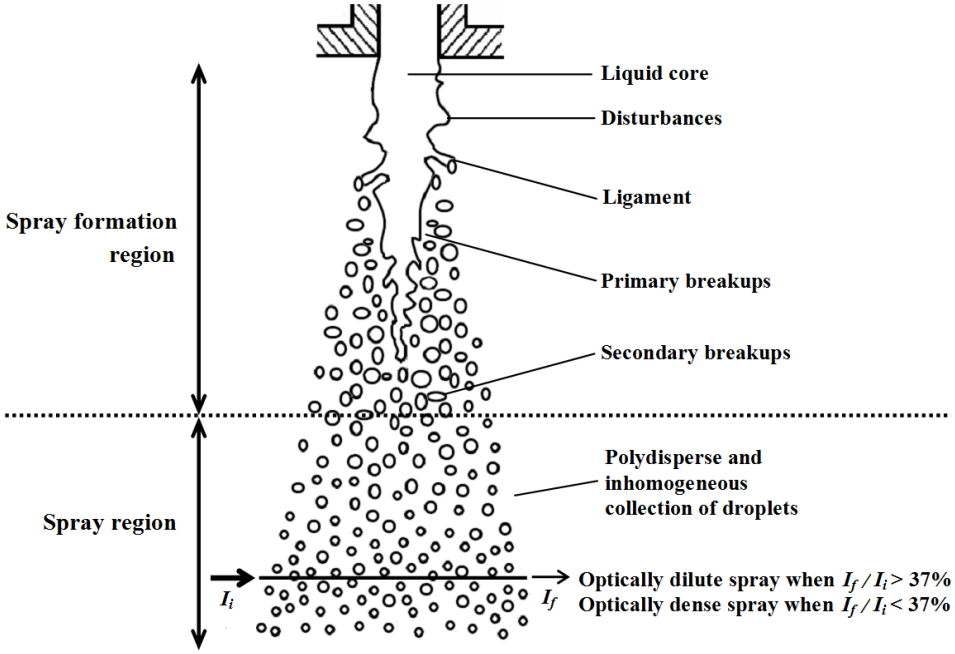

Figure: Illustration of the structure of an atomizing spray. The spray region can either be optically dilute or optically dense depending on the droplets number density, the droplets size and the illumination wavelength. As indicated in the figure a measure of light transmission I_f / I_i allows defining if the spray is optically dense or dilute for a given wavelength. The GPU-MC model presented here allows the simulation of a laser beam propagating through the spray region.

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