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In Application

2-Phase Spray Analysis based on Mie/Schlieren Imaging

Introduction

Sprays are essential to many industrial processes. Characterizing the complex spray behavior is necessary to optimize these processes. Liquid sprays break-up into droplets, atomize and often evaporate to mix with the surrounding gas. In order to fully analyze an evaporating spray both the liquid and vapor phases must be visualized. Qualitative line-of-sight information from both phases can be gained simultaneously by imaging Mie scattering of the liquid droplets and Schlieren imaging of the vapor phase.

Mie scattering is elastic light scattering caused by surface interaction. The wavelength is not changed. The signal strength is proportional to the surface area of the droplet. Mie scattering of liquid droplets can be achieved through planar illumination or as in the described system by global illumination of the entire spray.

Schlieren imaging is an established technique where changes in refractive index along a path of collimated light can be visualized. The changes in refractive index may occur through pressure, temperature gradients or changes in gas mixture.

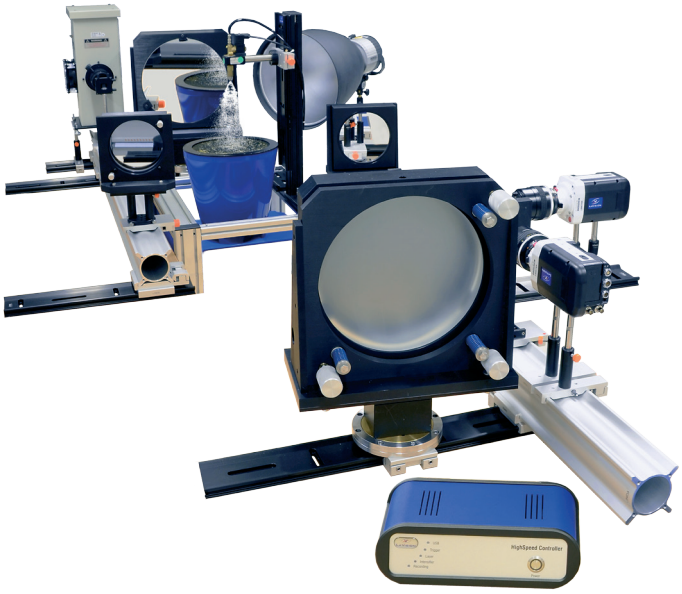

Figure 1: *Mie/Schlieren system for high-speed spray analysis*

Experimental Setup

Figure 1 shows an experimental setup of a combined Mie/Schlieren system. A high power incandescent light source with red color filter generates a point light source for the Schlieren imaging. Two 300 mm diameter parabolic mirrors are used to collimate and refocus the light passing through the spray. The point light source is refocused onto a fully adjustable Schlieren knife edge. A high power flash lamp with green color filter is used to illuminate the spray. A band pass filter is used to separate the green Mie scatter and red Schlieren images, which are then captured by two high-speed cameras. Alternatively a single RGB camera can be used. In this setup a Field of View (FoV) of 300 mm diameter and a temporal resolution of several kHz with exposure times down to 2 µs are achieved. FoV and temporal resolution are scalable to any application by selection of appropriate optics, cameras and light source.

The system is setup in two independent parts: illumination side and detection side. This allows for easy integration around any type of experiment such as a spray chamber or wind tunnel.

System Features

- liquid spray visualization by Mie scattering
- vapor visualization by Schlieren imaging
- phase separation by color
- multi-phase display in RGB format
- scalable FoV and temporal resolution

LaVisionUK Ltd
2 Minton Place / Victoria Road
Bicester, Oxon / OX26 6QB / United Kingdom
E-Mail: sales@lavision.com / www.lavisionuk.com
Phone: +44-(0)-870-997-6532 / Fax: +44-(0)-870-762-6252

LaVision GmbH
Anna-Vandenhoeck-Ring 19
D-37081 Göttingen / Germany
E-Mail: info@lavision.com / www.lavision.com
Tel. +49-(0)551-9004-0 / Fax +49-(0)551-9004-100

LaVision Inc.
211 W. Michigan Ave. / Suite 100
Ypsilanti, MI 48197 / USA
E-mail: sales@lavisioninc.com / www.lavisioninc.com
Phone: (734) 485 - 0913 / Fax: (240) 465 - 4306

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Evaporating Acetone Spray

The Mie/Schlieren system was used to analyze an evaporating acetone spray in ambient air. Figure 2 shows the Mie image visualizing the liquid spray while Figure 3 shows the Schlieren image showing the evaporating acetone in the surrounding air. Once the images have been spatially corrected the two phase information is superimposed in an RGB image as shown in Figure 4. The liquid phase is shown in green and the vapor phase in red.

Applications

- simultaneous visualization of liquid and vapor phases
- spray geometry, shape
- evaporating sprays
- automotive fuel sprays

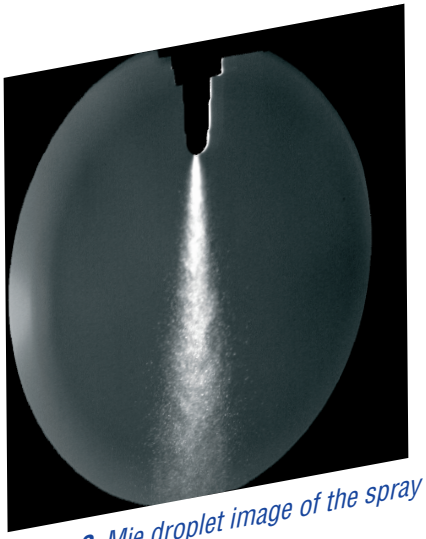

Figure 2: *Mie droplet image of the spray*

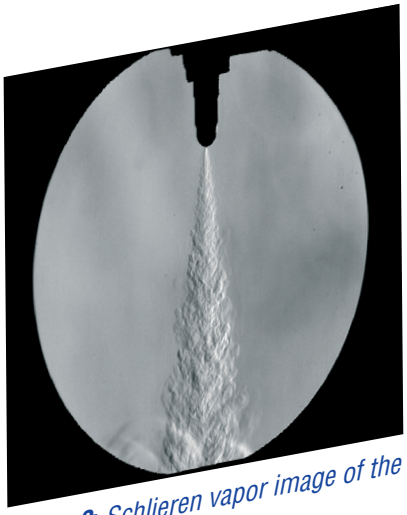

Figure 3: *Schlieren vapor image of the spray*

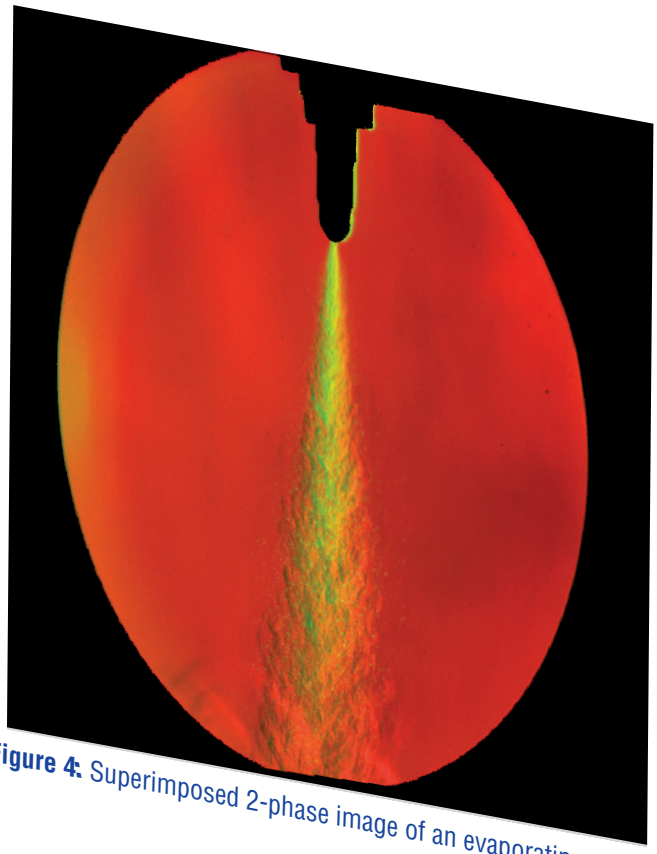

Figure 4: Superimposed 2-phase image of an evaporating spray

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Bicester, Oxon / OX26 6QB / United Kingdom
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Phone: +44-(0)-870-997-6532 / Fax: +44-(0)-870-762-6252

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Anna-Vandenhoeck-Ring 19
D-37081 Göttingen / Germany
E-Mail: info@lavision.com / www.lavision.com
Tel. +49-(0)551-9004-0 / Fax +49-(0)551-9004-100

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Ypsilanti, MI 48197 / USA
E-mail: sales@lavisioninc.com / www.lavisioninc.com
Phone: (734) 485 - 0913 / Fax: (240) 465 - 4306