LaVision
FOCUS ON IMAGING

In Application

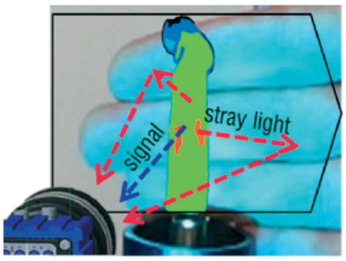
Scalar Laser Imaging without Stray Light

Background-free LIF and Rayleigh imaging

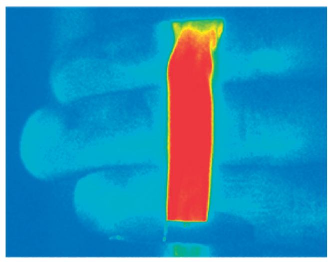
Introduction

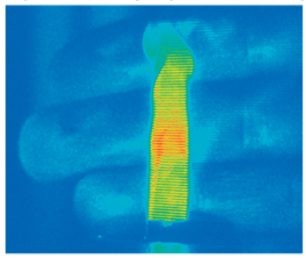
Laser imaging based on LIF or Rayleigh scattering is suffering from stray light interferences when applied close to surfaces. While ambient background light is effectively eliminated using short camera exposures in combination with spectral filtering, signal photons from the light sheet, which are scattered from the surrounding environment, are not removed. This unwanted stray light adds to the desired signal photons reaching the camera lens directly from the light sheet.

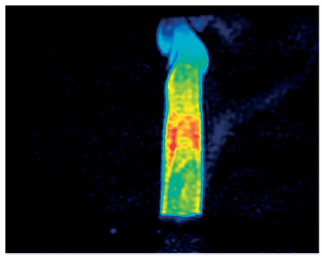
Structured **L**aser **I**llumination **P**lanar **I**maging (**SLIPI**) is well known for effective stray light suppression. The recently developed 1-pulse (1p-) SLIPI method enables instantaneous stray light free laser light sheet imaging at the expense of slightly decreased spatial resolution. In 1p-SLIPI the intensity modulated light sheet is filtered in the Fourier domain to eliminate the unmodulated stray light component.



Signal & stray light scattering

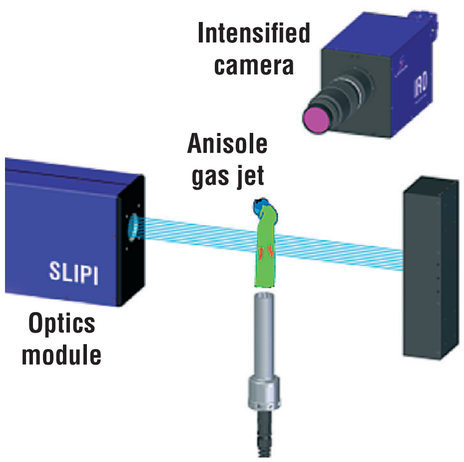

LIF image with stray light


Structured light sheet imaging

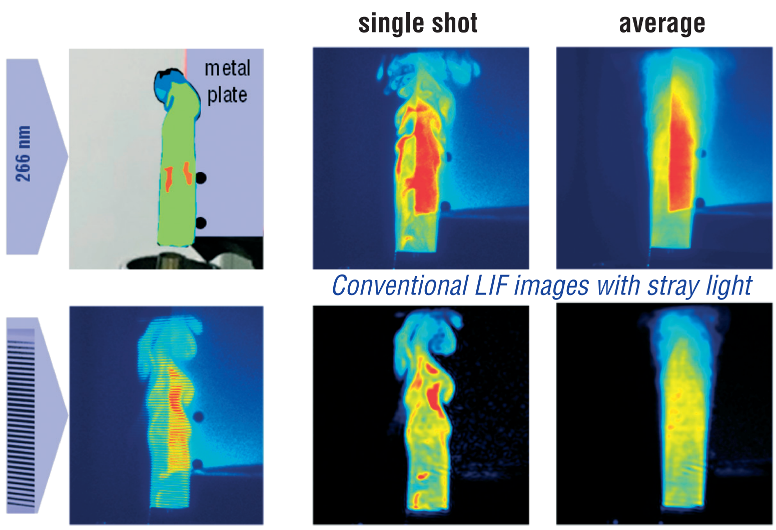

SLIPI LIF image w/o stray light

LIF imaging in gas jets close to surfaces

A **FluidMaster** LIF imaging system was used with and without SLIPI optics to visualize an anisole seeded gas jet in front of a metal plate. While the conventional light sheet LIF images (single shot as well as average) show clearly the stray light in the background interfering with the LIF signals from the gas jet, the SLIPI recorded and corrected LIF images show the desired black background without any stray light contributions. Thus, the SLIPI technique allows instantaneous LIF imaging even in close vicinity to reflecting surfaces.



LIF imaging setup for SLIPI LIF recording in a gas jet



Conventional LIF images with stray light

SLIPI LIF image

SLIPI corrected LIF images w/o stray light

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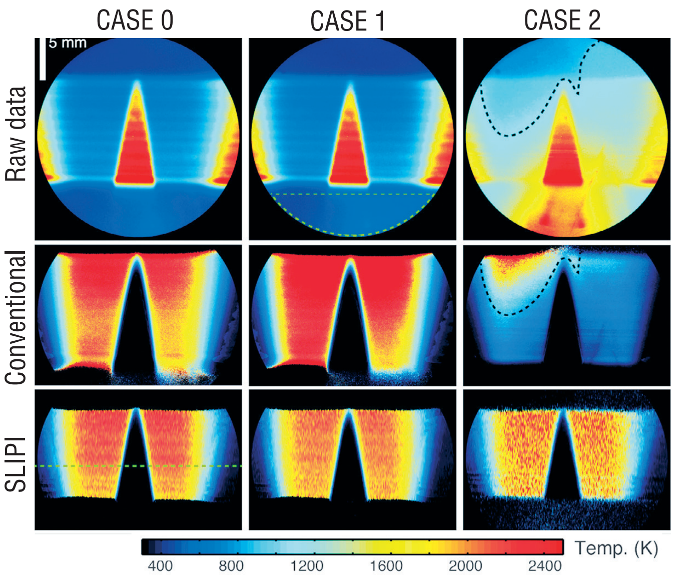
Scalar Laser Imaging without Stray Light

Background-free LIF and Rayleigh imaging

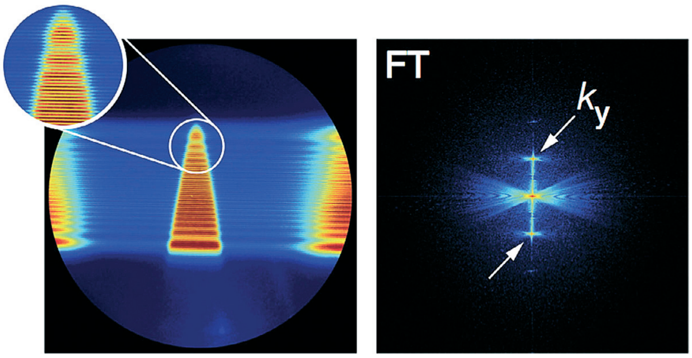
Background-free Rayleigh thermometry

Rayleigh photons are elastically scattered laser photons from gas molecules within the laser light sheet. Multiply scattered Rayleigh photons cannot be easily separated from singly scattered ones simply by time gating or spectral filtering. But this separation is possible applying 1p-SLIPI at only moderate reduction of spatial resolution. Lund University compared conventional with 1p-SLIPI Rayleigh thermometry at 532 nm for flame temperature imaging in a laminar CH_4/air test flame at three stray light levels labeled case 0, 1 and 2 [1]. In case 0 the Rayleigh imaging was free of stray light, case 1 suffered from weak stray light and case 2 showed strong stray light interferences.

Under stray light-free conditions (case 0) conventional and 1p-SLIPI temperature maps agree well (see figure below) measuring both the expected adiabatic flame temperature in the laminar CH_4/air test flame. However, as the stray light effects are increased as realized in cases 1 and 2, respectively, the conventional laser sheet method suffers from these laser induced background interferences resulting in wrong flame temperature images.



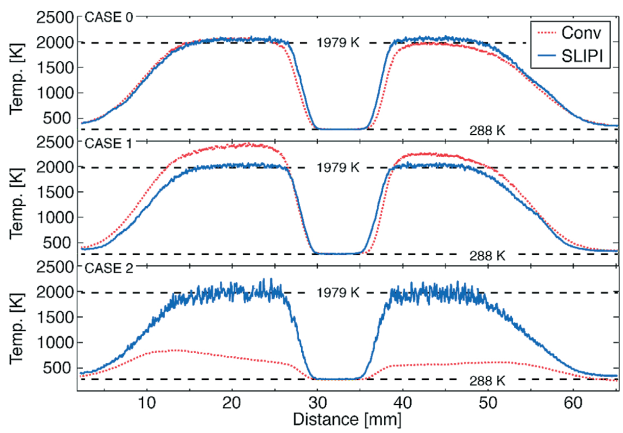
Rayleigh thermometry carried out at different stray light levels. Conventional light sheet imaging is compared with SLIPI recordings.



Structured Rayleigh image with its Fourier transform

In contrast, Rayleigh thermometry using the 1p-SLIPI method measures in all three cases the correct flame temperature field even under the strong stray light condition of case 2.

The presented results show clearly the benefits of the SLIPI technology for Rayleigh thermometry in stray light contaminated environments. All LaVision's scalar laser imaging systems can be upgraded right away with the necessary SLIPI hardware and software modules for stray light-free laser imaging.



Flame temperature profiles measured with conventional light sheets and SLIPI recordings for three different stray light levels.

LUND UNIVERSITY

Reference

[1] E. Kristensson, A. Ehn, J. Bood, M. Aldén, "Advancements in Rayleigh scattering thermometry by means of structured illumination", Proceedings of the Combustion Institute 35 (2015)

05/18

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