LIF System for Mixing and Scalar Transport

Planar-LIF solutions for liquid applications

Concentration and temperature imaging for liquid mixing studies

Our planar Laser Induced Fluorescence (LIF) systems for diagnostics of mixing and scalar transport in liquids are specially designed to handle whole-field concentration or temperature measurements which can be synchronized with simultaneous velocity measurements if desired. In addition to DynamicStudio’s powerful capabilities for image acquisition and visualization, the mixing LIF software enables the user to easily process images of fluorescence and extract statistics, Reynolds fluxes and other information from the images for a better understanding of the process investigated.

Key benefits

- Non-intrusive imaging technique for studies of liquid mixing phenomena
- Wide range of high-sensitivity cameras
- Complete software platform for system setup, data acquisition, data analysis and visualization of results
- Dedicated software for concentration and temperature calibration and processing
- Fully compatible with Dantec Dynamics’ PIV systems for combined, multi-parameter measurements
The liquid LIF solutions in brief

Dantec Dynamics’ planar-LIF solution for concentration or temperature measurements in liquids makes challenging measurement tasks simple. It is comprised of an Nd:YAG laser with light-sheet optics, a camera equipped with the appropriate lens and detection filter, electronics for hardware synchronization and analogue sampling devices. In addition, the software offers data acquisition, data visualization and straightforward image processing with built-in calibration capability, robust analysis methods and full import/export functionality.

Overview of the different components, timing and data flow.

Laser light sources

Concentration and temperature planar-LIF measurements are carried out using Nd:YAG lasers, available in a variety of repetition rates and energy outputs. With simple setup and operation, the light-sheet optics give you freedom to adjust the thickness and divergence angle of your sheet for greater experimental flexibility.

For your special, optically-demanding measurements, Dantec Dynamics has designed light-guiding systems to enable measurements without compromising safety:

- Light guide arm for measurements in confined systems
- Underwater illumination optics
- Endoscope

Cameras and lenses

Dantec Dynamics offers a range of cameras with various pixel resolution, light sensitivity and image bit-coding characteristics:

- The FlowSense EO series is comprised of several models with high performance at an affordable price. Offering a wide range of sensor resolutions up to 29 MP, the FlowSense EO series cameras can accommodate most planar-LIF application in liquids.

- The HiSense Zyla camera combines high resolution and high sensitivity. Featuring exceptionally good signal to noise ratios, this camera is especially well-suited for low light intensity measurements. Combined with its 12/16 bit dynamic range, the HiSense Zyla camera is an excellent choice for all intensity-based measurements.

Pixel binning and active sensor size definition are available on each type of camera, so the frame rate can be increased if required. Additionally, a wide selection of lenses is available to optimize the magnification and field-of-view (FoV) for each measurement.

Performance Synchronizer

The Performance Synchronizer ensures that all devices perform their individual tasks at the correct time. The device is a powerful tool for handling not only the image acquisition, but also the simultaneous synchronization and timing of other sensors or external devices in the experimental/industrial setup.

The Performance Synchronizer is integrated into the DynamicStudio imaging software platform for easy setup and configuration, and comes with both USB and Ethernet communication.
The use of the Ethernet interface makes it possible to place the synchronizer near the experiment and the PC in a control room at some distance. Main devices are auto-detected, which ensures that the user will not have to enter any specific properties for the system. The connectivity diagram in the software shows how to properly connect the synchronization cables. The Performance Synchronizer provides the option for analog signal sampling. The analog sample can be the temperature from a sensor (e.g. during temperature planar-LIF calibration), a reference velocity (e.g. from a CTA probe during synchronised PIV/planar-LIF measurements), or simply the energy of each laser pulse using our laser Pulse Energy Monitor. The signal may be sampled with or without a user-defined delay relative to the laser flashes.

**Starter kits “Dye & Filter” for liquid mixing applications**

In addition to the system hardware, two starter kits are available, containing consumables and minor components that come in handy for making experiments in liquids. The kits include:

- The fluorescent marker (powder) dedicated to your needs (concentration or temperature measurements according to the type of laser used)
- A well-documented information booklet on the chemical and spectral properties of the dye purchased (and others you may use in the future)
- A risk and safety handbook to help you handle your compounds appropriately
- A long-pass filter to mount on the camera lens, blocking any scattered laser light and transmitting the fluorescence from the dye

**User-friendly imaging software platform - Straightforward data analysis**

The image acquisition system is based on DynamicStudio, a comprehensive and user-friendly software platform for imaging applications. It features an advanced plug-and-play-based distributed system, making it easy for the user to maintain full control over the hardware for image acquisition. Data acquisition and analysis are supported within the same software, so there is no need to export the data for continuing with the analysis.

With easy access to numerous numerical methods, along with quick and accurate calibration and processing methods, users will experience the benefits of working with a truly integrated solution. And with the intuitive interface, only a few clicks are required to acquire planar-LIF or synchronized PIV/planar-LIF experimental data. The mixing LIF software features robust and interactive methods for:

- Calibration with respect to concentration or temperature measurements alone; or concentration (or temperature) with multiple laser energy levels (bimodal calibration routines)
- Processing raw images directly using the calibration defined previously
- Statistics on LIF images and scalar maps
- Reynolds flux
- Post-processing routines
- Combining LIF and PIV results if applicable

As a part of the main package of DynamicStudio, the Image Processing Library (IPL) software extends image analysis possibilities. A variety of numerical methods offer quick access to image enhancement, filtering and advanced numerical processing.
Boosting analysis capabilities with analysis sequences and MATLAB® Link

The data analysis is further strengthened by the ability to define analysis sequences and perform batch processing; this significantly speeds up the process of working with large data sets. And with the MATLAB Link in DynamicStudio, you can tailor your analysis by calling up custom MATLAB scripts directly from DynamicStudio, allowing you to process the data directly in the database without the need to first export the data.

Processed and post-processed images (average and rms) of PIV/planar-LIF measurements are used to determine Reynolds flux $(u'^c, v'^c)$ vector map in a turbulent water jet in a cross-flow.

Options

Dedicated imaging optics for synchronized PIV/planar-LIF measurements

For advanced mixing studies, LIF can be combined with PIV; e.g. when Rhodamine B dye is excited by the same Nd:YAG double-pulsed laser used as light source for the PIV technique.

Dual-camera mount (two cameras)

Save precious time when aligning two cameras to view the same area of the flow by using Dantec Dynamics’ Dual-camera mount in combination with the numerically robust methods of the planar-LIF software. In DynamicStudio, the user can apply the same operation (region of interest selection, zoom in/out, image browse, etc.) to both images acquired. Calibration functions within DynamicStudio can also be applied directly.
Cost effective solution using DualScope (single camera)

DualScope is an optical splitting system that allows simultaneous acquisition of two spatially identical but spectrally separated images simultaneously with the use of only one single camera. With this unit, combined LIF and PIV can be carried out with only a single camera, which reduces both the cost and the complexity of the measurement. The optics of DualScope are optimized to help imaging overlapping and minimize parallax distortion. Dedicated filters for LIF and PIV (with standard thread for camera lenses) can be mounted directly onto the DualScope.

Pulse Energy Monitor

A proven method of reaching higher accuracy is to measure the laser’s pulse-to-pulse fluctuations by means of a Pulse Energy Monitor and subsequently compensate for this during LIF image analysis. The Pulse Energy Monitor is mounted between the laser output and the light-sheet optics.

Product overview

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