# Measurement of droplets size-temperature correlations in sprays with combined 3-color LIF and PDA techniques

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**Keywords:** LIF, spray, PDA, temperature

Heat and mass transfer in sprays is a key problem in the understanding of complex phenomena related to vaporization of liquids in system using sprays for combustion, freezing, or cooling. In such a process, the droplet size distribution as well as spray concentration must be optimized in order to improve the heat transfers. For example, the average droplet heating time in a combustion chamber or the heat flux extracted by a spray impacting onto a hot surface is strongly linked to the droplet size distribution. In all these situations, heat transfers in the spray can be well characterized by the local liquid phase temperature, which is strongly correlated to the droplet size distribution. The present contribution is devoted to the development of an optical diagnostic combining 3-color laser-induced fluorescence and PDA in order to determine the mean droplet temperature per droplet size class. The PDA is a well-established instrument to measure droplet size and velocity and the three-color LIF technique has been recently developed to measure liquid temperature. Three-color LIF requires the use of a fluorescent molecule added to the liquid, which is temperature sensitive. The fluorescence is induced by a suitable laser excitation. The fluorescence spectrum depends on local temperature, number of molecules emitting fluorescence, excitation intensity and fluorescence scattering along the path between the probe volume and the detector surface. Three detection spectral bands are used to measure two fluorescence ratios. The ratio between the fluorescence signals measured on the two first spectral bands allows eliminating the influence of the number of emitting fluorescent molecules, excitation intensity [1]. However, this ratio presents a significant sensitivity to the fluorescence scattering phenomena induced by the surrounding cloud of droplets. An additional spectral band of detection is selected so as to obtain a ratio between the signals measured on the second and third spectral band which is independent on temperature and only sensitive to the fluorescence scattering [2]. The use of these two combined fluorescence ratios and a set of initial calibrations make it possible to derive the local spray temperature. The same laser source and emission optics are used to induce the fluorescence of the droplets and for the PDA measurements. Both LIF and PDA acquisition systems are synchronized to the same clock. Two acquisition files (PDA and LIF) are post-processed in order to match the events detected by the two systems and finally the droplet temperature averaged by droplet size class is derived. The range of detection of the LIF and PDA techniques, in term of droplet size, is discussed in the light of calculations performed by Generalized Lorentz Mie Theory. The position of the LIF and PDA detectors are also addressed and two configurations are critically compared: - detection of the LIF signal in the back direction and Mie scattered light, for the PDA measurements, in the forward direction, - detection of the LIF and Mie scattered light with the same optics in the forward direction. A demonstration experiment is carried out in an ethanol spray injected in an overheated wind tunnel (air temperature, 100°C,co-flow velocity, 6.3 m/s). The temperature determined at different radial positions (50 mm downstream of the injection nozzle) exhibits a clear dependence on the droplet diameter, the biggest droplets being colder, which is compatible with the heat diffusion within the droplets (Fig. 1). The first results of correlation between droplet size and temperature are given in the paper and the optimal detection configuration is detailed. Such a new investigation tool can be used to study heat and mass transfer phenomena in sprays and to investigate more challenging topics like mixing of sprays.

## References

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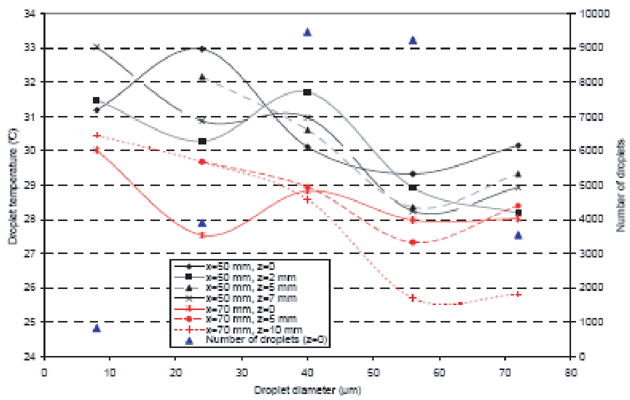


Fig. 1: Evolution of the droplet temperature as a function of the droplet diameter for different radial positions. The number of droplets used in the averaging process is also indicated.