New insight into two-color LIF thermometry applied to temperature

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To measure properly the temperature, the concentration and the size distribution of droplets in sprays, only non-intrusive optical methods have the potential to provide these parameters such as Phase Doppler Anemometry [1] or global rainbow thermometry [2]. Other techniques are based on laser-induced fluorescence of a tracer dissolved in the liquid to be sprayed [3].

Here, a new optical diagnostic that aims to measure the droplet temperature measurements in sprays based on the two-color laser-induced fluorescence (LIF) is presented. The principle of the two-color LIF technique is to induce the fluorescence of a tracer previously seeded in the liquid of interest. The use of two spectral bands allows calculating a ratio of fluorescence intensities \( R_{12}/R_{120} \) that depends only on temperature [4-5]. Nevertheless, in the case of sprays, due to the particular spray environment, such as the size distribution of the droplets or spray density, the two-color LIF technique cannot be used directly. More precisely, in a previous paper [6] it has been highlighted that the fluorescence ratio increases widely when the diameter \( D \) of mono-disperse calibrated droplets decreases whereas the temperature is assumed constant.

The present paper aims to investigate more thoroughly the non-linear size effect and its coupling with other phenomena, such as multiple scattering of the laser light which induces off-field fluorescence. For that purpose, combined LIF and PDA measurements have been implemented. This technique allows achieving fluorescence ratio per droplet size class. Nevertheless, a new phenomenon, different from those of the droplet size effect, has appeared in the first results obtained. Figure 2 presents typical results (ratio \( R_{12}/R_{120} \) as a function of the diameter \( D \)) obtained with combined LIF/PDA technique collected in a spray.

It appears that, the curve for the \( P_{inj} = 2.5 \) bars seem well superimposed with mono-disperse droplets data whereas for higher injection pressures, the curves are shifted to higher values of \( R_{12}/R_{120} \). This new effect could be interpreted by the strongly coupling between the size effect and the multiple scattering of the laser light which induces off-field fluorescence. Indeed, if the depth of field of the collection optics is too large, the collected fluorescence signal is the addition of the contributions of the fluorescence induced in the presumed volume and the florescence induced outside this volume in the depth of field of the collection optics. This unwanted fluorescence could induce a new bias in the fluorescence ratio. Therefore, a long distance microscope (QM-100; Questar®), with a lower depth of field, is used and tested. In Figure 3, it is described same results as those presented in Figure 2 and with the same conditions.

In this case, curve for 4.5 bars seems superimposed with the mono-disperse one. More, the curve for 7 bars is shifted toward lower \( R_{12}/R_{120} \) values and tends to the mono-disperse one.

Fig. 2 Results of LIF/PDA measurements obtained with a long-distance microscope having a low depth of field.

References