Methane-air flame thermometry using Planar Laser-Induced Fluorescence (PLIF)

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Planar laser-induced fluorescence (PLIF) method of diagnostics [1-3] employs laser radiation to selectively excite electronic energy levels of probe molecules and radicals (OH in our case). The excitation laser beam is configured to the planar geometry to achieve two-dimensional spatially-uniform irradiation of the area of interest. The target molecule emission occurs both from the laser-excited level and from other levels populated by molecular collisions. After spectral suppression of the scattered radiation at the excitation wavelength, the fluorescence light from the laser beam plane is imaged onto a two-dimensional optical detector.

The ratio R of the PLIF signals obtained after resonant laser excitation of the probe molecules at two different wavelengths λ_1 and λ_2, contains information about local gas temperature T and for each pixel of the images may be described by the expression:

$$R = C\times(I_{\lambda1}/I_{\lambda2})\times\exp[-(E_i - E_k)/kT],$$

where $I_{\lambda1}/I_{\lambda2}$ is the ratio of the incident laser light intensities, k is the Boltzmann constant, $(E_i - E_k)$ is the difference of the energies of the initial levels, while the coefficient C takes into account Einstein coefficients and Franck-Condon factors for the corresponding transitions, as well as collisional deactivation rates for the upper levels. Determination of the coefficient C in one pixel of the image allows deriving spatial temperature distribution from the PLIF signals.

In this work, spatially-resolved PLIF temperature measurements were performed in a partially premixed flame of a laboratory methane-air burner, previously characterized using coherent anti-Stokes Raman scattering (CARS) [4]. PLIF of OH radicals was excited by frequency-doubled radiation of a narrow-band dye laser at two different lines of the (1-0) band of the $X^2\Pi - A^2\Sigma^+$ electronic transition. For this purpose, the image processing algorithms were developed, and the temperature calibration procedure was realized.

References

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