Simultaneous determination of time and length scales of local temperature fluctuations in a turbulent flame by using coherent anti-Stokes Raman spectroscopy

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Determination of time and length scales of local gas temperature fluctuations in a turbulent flame by using coherent anti-Stokes Raman scattering (CARS) spectroscopy has been demonstrated for the first time. Two CARS-spectrometers [1] with synchronized 10 ns pulse duration 10 Hz repetition rate lasers were employed to perform two-point "instantaneous" temperature measurements by recording series of single-shot CARS spectra of N_2 molecules at a variable temporal delay between two sequential laser shots following each other in pairs. The spectra were obtained from two small probe volumes ($0.03\times0.03\times2$ mm^3) separated from each other by a variable distance in an open partially-premixed methane-air flame. From the spectra, series of temperatures at certain delays [2] and/or distances were derived. The obtained values enabled calculation of the time, space and space-time correlation coefficients of temperature fluctuations *vs* the delays and distances and thus evaluation of characteristic time and length scales of these fluctuations.

The results are presented for the series of 500 single-shot coupled measurements of temperatures at the delays in the range 0.1 μs-10 ms and the distances from 0.2 to 2.5 mm in a few spatial points of the flame with the average temperatures between 1200 and 1800 K and different visually distinguishable stability of combustion. The measurements, performed at various mixture flow rates and equivalence ratios, provided correlation times in the interval 100-400 μs and correlation lengths, across or along the flame axis, about 1-2 mm. The results show that, based on temperature correlation coefficients, mean axial flow velocity can be evaluated, and fuel and oxidizer mixing quality can be characterized.

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References

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