A detailed experimental and theoretical comparison of spatially-resolved laser-induced incandescence signals

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To improve LII as a quantitative tool for extraction of soot properties, the models describing the heat and mass transfer between the particles and the surrounding gas must be tested against well-characterized experiments. In this work we have made a detailed investigation in which experimental results have been compared with simulated ones in two different configurations; backward-LII and 90º-LII. Although the results show a qualitatively good agreement, it is realized that an improved physical description is needed for the LII signal behavior.

Introduction

The laser-induced incandescence (LII) technique has evolved as a powerful technique for quantitative measurements of soot volume fraction as well as of particle size. Still, however, fundamental knowledge of the processes underlying the signal behavior is partly unknown, which motivated the present work.

Experimental and theoretical approach

Experiments were performed in an axisymmetric methane diffusion flame. The central part of a Nd:YAG laser beam at 1064 nm was directed through the flame, and the spatial distribution of the laser beam was monitored. The spatially resolved LII distributions were imaged in two directions of observation, see Fig.1.

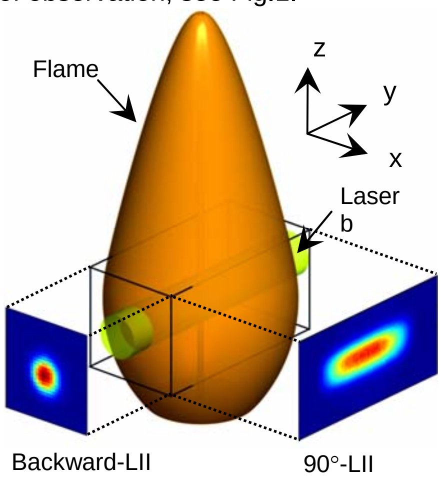

Fig. 1: Backward-LII and 90º-LII and their relation to the measurement volume.

Two-dimensional images of spatial LII distributions were recorded for both experimental configurations as a function of laser pulse energy and using different gate timings.

The heat and mass transfer model for the soot particles heated by laser radiation calculates time-resolved LII signals for a given set of input parameters [1]. Integrated LII signal intensities were calculated from simulated measurement volumes created using data from the experiments, such as the spatial distribution of laser energy.

Results

An example of experimental data is shown in Fig. 2, where simultaneous images are shown for both backward-LII and 90º-LII. In both images strong vaporization can be seen at the center of the spatially resolved LII signals.

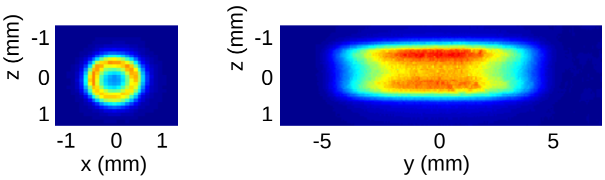

Fig. 2: Spatially-resolved LII signals from experiments using backward-LII (left) and 90º-LII (right).

In the comparison of experimental data with simulated ones, it was shown that the effects of the non-homogeneous laser energy distribution and the vaporization characteristics were qualitatively well reproduced by the model. The presented results are important in the further development of the LII model.

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