Pulsed laser heating of differently aged soot probed using LII and ELS

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Laser-induced incandescence (LII) is a laser-based technique for measuring soot particle sizes and soot volume fractions e.g. in flames, furnaces and exhaust gases. The basic principle of the technique is a rapid heating of soot particles with pulsed laser light and then detecting the increased incandescence. During the last two decades LII has been extensively refined and evolved to one of the standard techniques when conducting in situ measurements on soot particles. However, there are still refinements to be made, not least in understanding the interaction between laser light and soot, which is crucial information in the evaluation process where this interaction is modeled together with the subsequent cooling of the soot particles.

In this work the heating and vaporization effects of the LII laser pulse on differently aged soot have been studied by a combination of LII and elastic light scattering (ELS) with an experimental procedure similar to the one used in [1], but with additional possibility for pyrometry using two-color LII. By using an Nd:YAG laser at 1064 nm for the LII and another at 532 nm for ELS, and intersecting the laser beams in the probe volume, the elastic scattering can be utilized to probe heating and vaporization effects of the 1064 nm laser light. To generate the soot particles a McKenna type burner has been used, where the soot growth can be followed from nascent soot particles close to the burner surface to more mature soot higher up in the flame.

Results show a significant difference as a function of height above burner (HAB) as seen in Fig. 1. This behavior could be explained by a variation in both the absorption function, E(m), and the sublimation threshold at different HAB i.e. for differently aged soot. Furthermore the results reveal an effect not discussed in [1], namely a slight increase of the scattering signal from soot just before the rapid decrease due to vaporization, seen in Fig. 2.

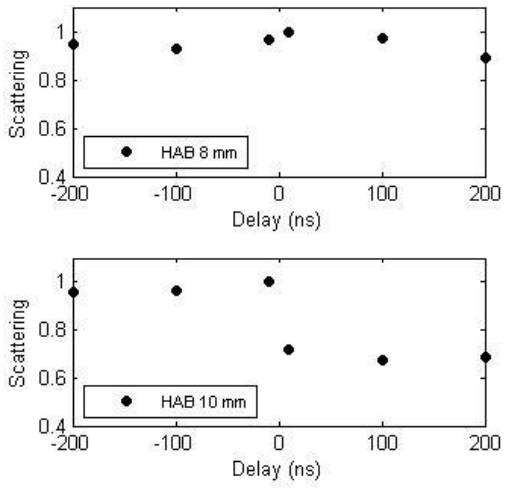

Figure 1 Normalized ELS signal before and after an LII laser pulse with fluence 0.3 J/cm^2. Top plot shows measurement at 8 mm HAB and bottom plot at 10 mm HAB.

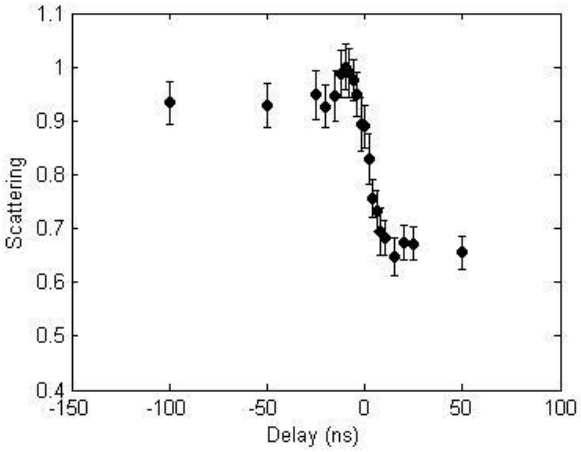

Figure 2 Normalized ELS signal before and after an LII laser pulse with fluence 0.3 J/cm^2 at 10 mm HAB.

[1] G. D. Yoder, P. K. Diwakar, D. W. Hahn "Assessment of soot particle vaporization effects during laser-induced incandescence with time-resolved light scattering", Appl. Opt. 44 (2005)