Modeling laser-induced incandescence of soot integrating spatial and temporal dependences of parameters involved in energy and mass balances

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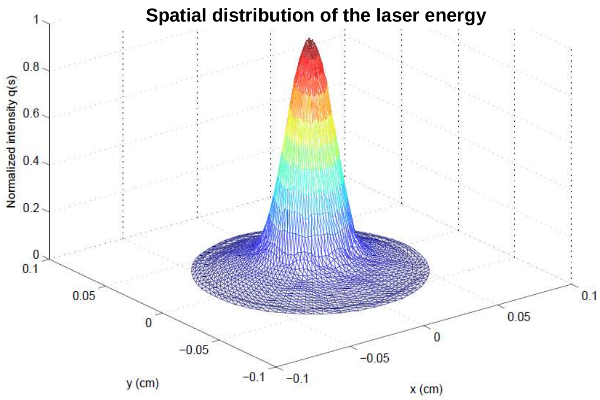
Laser-Induced Incandescence (LII) has become a widespread used technique for soot volume fraction and primary particle size determination in flames and exhaust gases. The correct interpretation of experimentally measured LII signals implies a detailed understanding of the physical mechanisms that control the LII phenomenon. It also needs, amongst other things, to thoroughly take into account the experimental parameters involved in the excitation process (especially the spatial and temporal profiles of the laser energy). Different models have been proposed recently in the literature to predict the temporal behavior of LII signals[1]. Nevertheless, except some recent works from Bladh et al.[2], only few works took into account the temporal and spatial characteristics of laser excitation sources presenting 2D inhomogeneous distributions.

In the present work, the experimentally monitored characteristics of an unfocused near-Gaussian laser beam have been considered as input data in our model (see the figure below). The spatial discretization of the mass- and energy-balance equations (based on the absorption (Q_{abs}), radiation (Q_{rad}), sublimation (Q_{sub}) and conduction (Q_{cond}) terms) has been carried out using the finite element method while the temporal discretization of these equations has been achieved following the Crank-Nicolson scheme. By this way, we obtain a matrix shape equations system in which the particles temperature and diameter (T_p and D_p, respectively) are the two unknowns. Such a 3D problem being non-linear, we solved it by using the Newton iterative method to obtain the evolution of T_p and D_p as a function of the time and of the space in each mesh of the excitation volume. The temperature dependence of parameters such as physical properties of soot has also been taken into account in the different terms used to obtain the mass- and energy -balance equations which allows determining the evolution of these properties for each time and spatial position.

A mesh sensitivity study has been carried out and the temporal evolution of Q_{abs}, Q_{rad}, Q_{sub}, Q_{cond}, T_p and D_p as a function of the space will be presented in this work which is still in progress. The spatial LII time decays that have been calculated by entering T_p and D_p into the Planck function integrated over a given range of wavelengths will be presented and potentially confronted with experimental data obtained using such a laser profile.



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