Probing combustion and other harsh environments using laser spectroscopic techniques

Marcus Aldén

Division of Combustion Physics, Lund University, P.O. Box 118, S-221 00 Lund, Sweden

Examples will be given from a variety of laser techniques, where high speed visualization, multi-species visualization and ways to detect "new" species will be highlighted both from a more fundamental perspective but also with several "real-world" applications.

Introduction

The importance of combustion processes for efficient and environmentally friendly energy conversion, e.g. for heat production and for transportation have encouraged research on new tools for a deepened understanding of these processes. During the last decades different laser diagnostic techniques have proven to be very valuable tools for measurements in harsh environments, e.g. different combustion situations. The main advantages with these techniques are the non-intrusiveness in combination with high spatial and spectral resolution. Parameters that can be measured are species concentrations (atoms, molecules, radicals), temperatures (vibrational, rotational, translational and electron), velocities and characteristics of particles (size, number density, volume fraction) and surfaces. The techniques that have been used can be divided into non-coherent and coherent techniques, where the former include, e.g. Mie, Rayleigh and Raman scattering, laser-induced fluorescence, whereas the latter include e.g. Coherent anti-Stokes Raman Scattering (CARS), polarization spectroscopy (PS), degenerate four-wave mixing (DFWM) and Stimulated emission (SE). See Refs. [1,2] for some overview articles.

Non-coherent techniques

Maybe the most important technique for diagnostics is laser-induced fluorescence, LIF, with which two-dimensional measurements can be made. It has also been shown that high speed, ~10-100 kHz, can be realized. In Fig 1 is shown high speed visualization of OH in a turbulent flame

Coherent techniques

As an alternative technique there are also Coherent techniques where the signal is generated as a new laser beam. An example is given in Fig. 2. Here H atoms are measured in 2D in a flame using polarization spectroscopy.

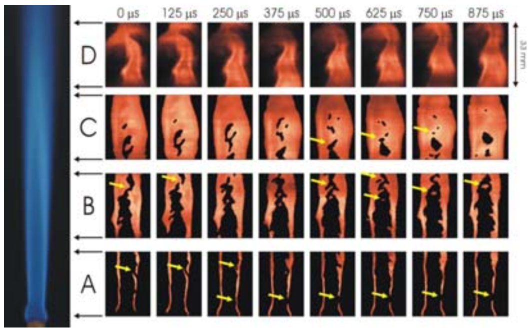

Fig. 1 *High speed visualization of OH radicals at different heights in a turbulent flame using laser-induced fluorescence*

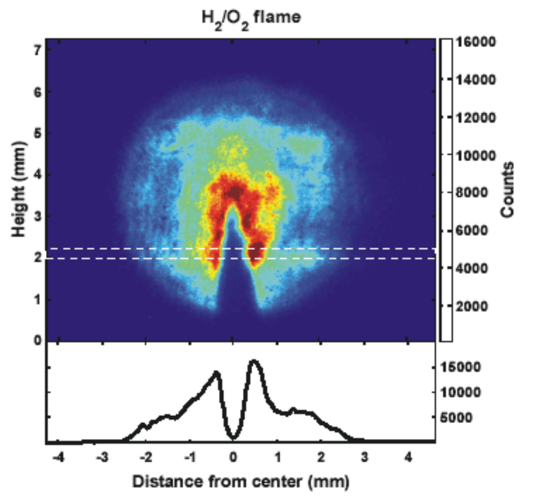

Fig 2. *Single shot distribution of hydrogen atoms in a flame measured with polarization spectroscopy*

References

[1]. K. Kohse-Höinghaus, R. S. Barlow, M. Aldén and J. Wolfrum, Combustion at the focus: laser diagnostics and control, Proc. Comb. Inst. 30, 89 (2005).
[2]. M. Aldén, J. Bood, Z. S. Li and M. Richter, Visualization and understanding of combustion processes using spatially and temporally resolved laser diagnostic techniques, Proc. Combust. Inst. 33, 69-97 (2011)