

## LASER INDUCED FLUORESCENCE (L.I.F.):

### LASER FOR THE STUDY OF COMBUSTION PROCESSES

Concerning the global dependence on fossil fuels and increasing constraints with respect to the emission of combustion-generated pollutants, the importance of a more detailed understanding of combustion processes can hardly be overestimated.

In this situation, Laser spectroscopic techniques serve two main purposes: they provide *in situ*, realtime information on technical combustion processes and they provide data for a full inspection of current model assumption.

Various parameters of interest, such as particle sizes, velocity, temperature and concentration distributions, can be determined using Laser spectroscopic methods.

For a complete analysis of the chemical processes governing combustion situations such as ignition, heat release, quenching or pollutant formation, accurate information, particularly on the behavior of reactive intermediates in combustion systems, can be measured using Laser absorption, Laser induced fluorescence, multi-photon spectroscopy or other less established techniques capable of detecting ppm levels of atomic and molecular radicals in combustion environments.

Among these, L.I.F. (Laser induced fluorescence), acquired from SSC in 2000, allows to find concentration distributions of hydroxyl radical, an important combustion intermediate, inside the flame front and to determine the temperature of the same flame by means of Rayleigh Scattering diagnostic.



Fig. 1 – L.I.F. diagnostic, acquired from SSC in 2000



## Principle of operation

The greater part of the intermediate radicalic species in combustion processes has bands of absorption in the UV and fluorescence spectrum in the range of 250-400 nm.

Fourth harmonic of a solid state Nd:YAG Laser tuned to 266,15 nm excites OH radical second A-X (2,0) transition, indicated as  $P_1(10)$ . The emission of fluorescence from part of the examined species during the deexcitation process, is detected from one ICCD camera with proper filters.

It is possible, in such a way, "to map" the hydroxyl radical and through a careful calibration it is possible to execute semi-quantitative measures.

Using a tunable Etalon, inside the emission radiation cavity, it is possible even to reach a different and tunable frequency.

In such a way Laser, a different frequency radiation, at 266,035 nm, can be produced, to carry out the thermometric measure in such conditions to attenuate or to completely eliminate the interference of the fluorescence signal.

Such measure is therefore based on the ICCD camera mapping of the radiation diffused to the same wavelength of the incident radiation (Rayleigh Scattering), from the molecules in the flame zone.

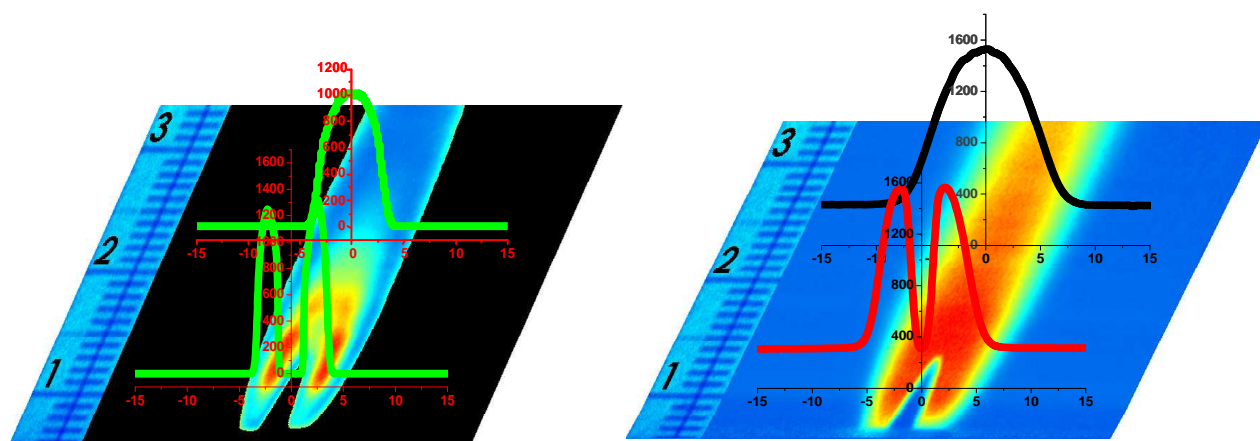


Fig. 2 – Acquired images from L.I.F. system: OH radicals distribution (on the left) and thermal field (on the right) of a flame with relative quantitative profiles acquired at two different heights of a Bunsen burner.



## Activities at SSC

- 1) Measure and mapping of the concentration (ppm) of OH radicals in flames, fed with various fuel, in real combustion systems, as instrument for the study of the complex interaction between the chemical, physical and fluidodynamic phenomena, that are the base of combustion and consequent formation of pollutants.
- 2) Determination of temperature's fields of flames, varying the operating conditions, as another way to understand the mechanisms of generation of pollutants like nitrogen oxides, whose formation depends strongly on the presence of local peaks of temperature.
- 3) Coupling of this advanced and powerful Laser diagnostic technique, like L.I.F., with chemical-kinetic modeling and fluidodynamic calculations for a better prediction of the behavior of the combustion systems.

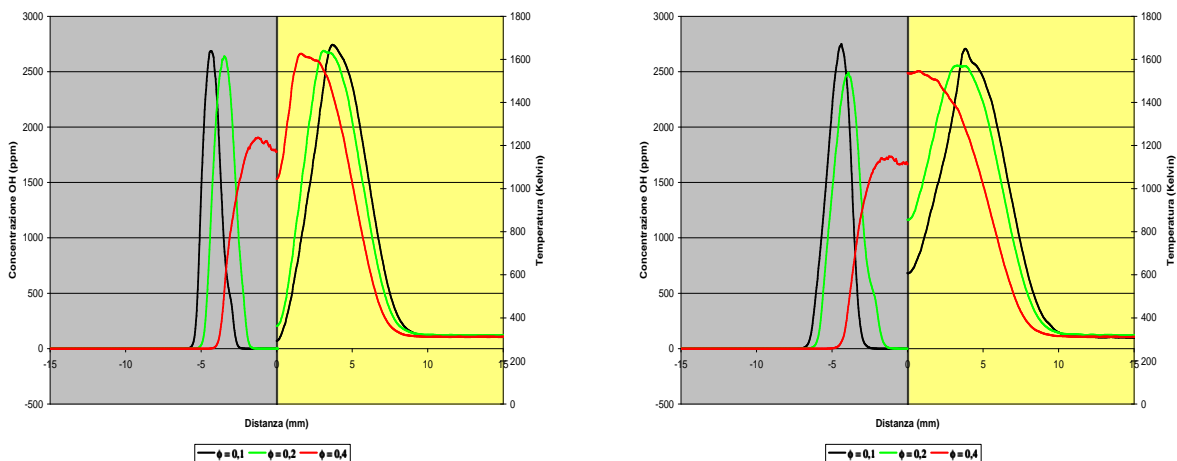


Fig. 3 – Flames profiles in different stoichiometric rates. OH radicals concentration in ppm (left half) and temperature in Kelvin (right half) varying the distance from the center of a Bunsen burner.

### Contacts:

#### Stazione sperimentale per i Combustibili

Viale A. De Gasperi, 3  
20097 San Donato Milanese, MI

Tel. 02 516041;

Fax 02 514286;

email [marengo@ssc.it](mailto:marengo@ssc.it) - [migliavacca@ssc.it](mailto:migliavacca@ssc.it)



May 2005