Application of two dimensional LASER induced plasma spectroscopy to the measurement of local composition in gaseous flows

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Laser Induced Plasma Spectroscopy (LIPS) allows quantitative and instantaneous measurements of atomic concentrations in a small volume.

![Diagram showing the setup of the LIPS experiment]

The principle is that plasma is generated by focusing a laser and its spectral emission is analyzed to recover the atomic composition of the medium at the location of the plasma. This non-intrusive technique is really efficient for the determination of gas composition. However, one strong limitation is that, when the light emission is collected through an optic fiber to the spectrometer, the measurement is averaged over the entire plasma surface.

In the present investigation, Laser Induced Plasma Spectroscopy (LIPS) is performed with an original two dimensional approach. The spectrometer usually used to record light emission from plasma and compare well-chosen peak intensity is here replaced by two intensified cameras equipped with band pass filters.

The 2D-LIPS technique requires the two cameras to be set up with exactly the same field of view, in order to compute the ratio of light intensity at two different wavelengths. As each pixel on the ICCD cameras corresponds to 20 x 20 µm field of view, a µm order accuracy is required in the spatial alignment. This order of spatial accuracy in the alignment of ICCDs cannot be obtained physically so the best alignment is computed by a numerical two-step image processing. The numerical processing involves application of an intensity threshold and digital filtering. This analysis reduces the fluctuations in the intensity ratios.

In order to relate the intensity ratios to atomic concentrations, it is important to know the amount of desired atomic emission intensity present in the total intensity seen by the camera. As the properties of the plasma change with time during the lifetime of the plasma, it is also important to find the best timing for the acquisition of the images. After correlating the images and finding the best timing for image acquisition, a calibration approach using well premixed conditions is developed to relate intensity ratios to concentration ratios. This calibration is then used to find concentration ratios in non premixed conditions.

The 2D-LIPS technique is tested on a configuration where the oxygen concentration varies with space. The technique proves to be able to reconstruct an air mixing layer of 4 mm thickness which is the same, with some fluctuations, as calculated from the hot wire measurements.

Although the thickness of the plasma is very small, i.e. 1.5 mm, but the oxygen concentration slightly changes in vertical direction as well proving the relevance and the needs for such 2D method.

The evolution of the technique offers two main advantages: both the spatial resolution and the volume of the measurement have significantly increased and simultaneously, data along the second transverse dimension are available with the same precision and resolution.

However, the method requires some improvements mainly to reduce the standard deviation when local concentration variations are becoming too intense. Finally, the method has to be tested in more realistic configurations where turbulence and/or diffusion have a chaotic impact on the flow motion.