Laser Induced Fluorescence in an atmospheric pressure RF plasma jet

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Introduction

Critical requirements for the detection of transient species in atmospheric pressure (ATP) discharges are sensitivity, time and space resolution. This is particularly true in plasma jets flowing towards a humid target, that are typical devices in plasma medicine applications. The gas mixture composition and the physics of the discharge strongly depend on the presence of the target, and local discharge conditions change in a sub-mm space scale. In addition the voltage source excitation is often pulsed. Laser Induced Fluorescence (LIF) is the technique that satisfies these needs. The spatial resolution of LIF can be a cylinder with diameter and height of the order of 0.1 mm, when focusing the laser beam. The temporal resolution is of the order of 10 ns. Both time and space resolutions of LIF are suitable for a detailed characterization of atmospheric pressure plasma jets. In this paper we present OH absolute measurements in a RF plasma jet together with a thorough discussion of the state of the arts of LIF technique.

LIF model

We address in detail the modelling of the LIF measurement, taking into account collisional processes and the spatial non-uniformity of the laser beam. Such a model is necessary in order to work in a partial saturation regime with a focussed laser beam. Focussing the laser is necessary to increase spatial resolution, but in such a way the linear regime is pushed down to energies lower than 0.1 µJ, resulting in a very low fluorescence outcome. The model is tested on the LIF saturation curve, as shown in Fig. 1. It takes into account rotational energy transfers in both the ground state and the laser excited state. In addition a gaussian spatial distribution of the beam energy is assumed (the laser beam is cleaned by a spatial filter). It is taken into account by space discretization into 17 sectors (annula) of the beam section (see Fig. 2) and by summing up the numerical solution of the model equations calculated for each sector. All the details can be found in [1].

Results

Results of OH concentration spatial maps by calibrated LIF in a He-H_2O RF plasma jet impinging on a commercial mixture of oilseeds target are presented. These measurements are complemented by corresponding measurements of air and H_2O obtained by the analysis of quenching and vibrational relaxation of the laser excited state [2, 3], and by gas temperature measurements achieved by a novel LIF excitation spectrum spectroscopic scheme.

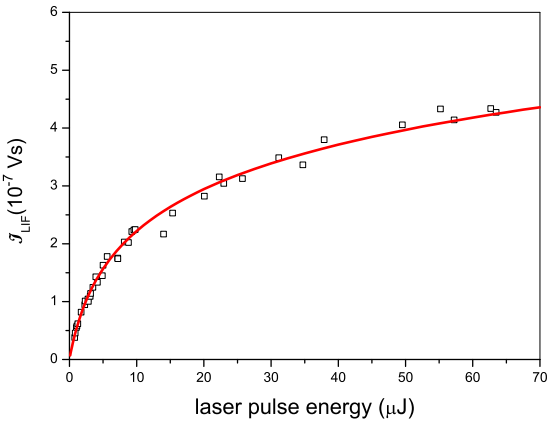

Fig. 1: *LIF saturation curve for a focussed gaussian laser beam with 80 µm waist. Comparison of model calculations (red line) with measurements (squares)*

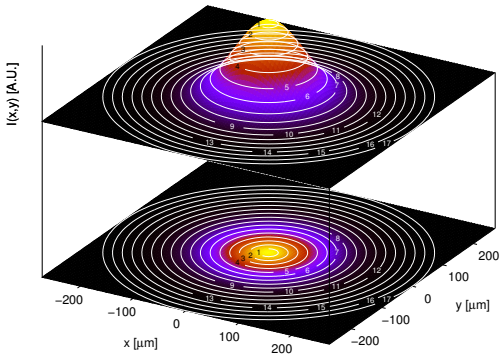

Fig. 1: *Discretization of the gaussian beam section into 17 sectors.*

References

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