Spatial characterization of N(^{4}S) and N(^{2}P) in the afterglow of a pulsed nitrogen discharge at atmospheric pressure using optical emission spectroscopy

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The use of the afterglow of a pulsed nitrogen discharge at atmospheric pressure is a promising technique for the decontamination of heat-sensitive medical devices (e.g. endoscopes). To get a better insight into the afterglow interaction with bacteria, the knowledge of the absolute densities of the potential bactericidal species is required, thus making the development of new diagnostic tools necessary.

Among the plasma diagnostics, optical emission spectroscopy (OES) is the most widely used technique. It has the advantage of being in situ and non-intrusive. However, to have access to the absolute density of a radiative excited state generally requires absolute calibration [1]. Here, we use a calibration-free method [2], named kinetic method, to measure the absolute density of N(^{2}P) metastable state and N(^{4}S) ground state Basically the kinetic method is based on the volume recombination mechanism of nitrogen atoms (reaction R1) and on the temporal evolution of N_2(B,v=11) state, which is proportional to the emission at 580 nm and results from nitrogen atoms recombination :

$$N(^4S)+N(^4S)+N_2 \xrightarrow{k_1} N_2(X, A, B) + N_2 \qquad (R1)$$

The kinetic method is then compared with the absolute calibration method, which is based on a direct measurement of the N(^{2}P) and N_2(B,11) states densities from their emission intensities at 346.6 nm and 580 nm respectively The arbitrary unit spectra were converted in spectral radiance units using a standard tungsten lamp, and then compared to radiance spectra simulated by Specair [3].

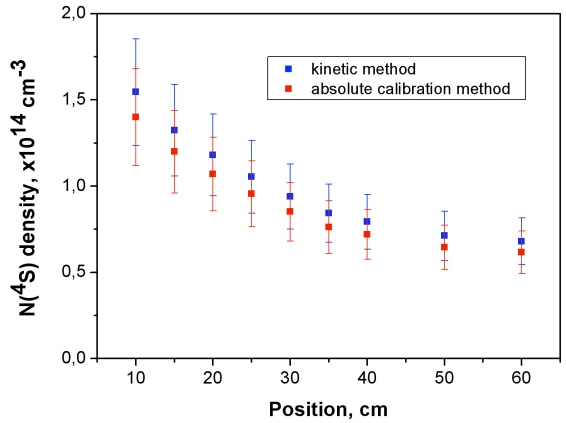
The two methods are applied to measure the longitudinal distribution of N(^{4}S) and N(^{2}P) in the post-discharge tube of a pulsed nitrogen discharge at atmospheric pressure. Radial distribution is also determined using Abel transformation.

The results obtained are shown in Fig.1. Using the rate constants measured in Ref. [4], the kinetic method is in good agreement with the absolute calibration method over an afterglow length of 50 cm.

Furthermore, a kinetic model based on the ZDPlaskin solver [5] was used to reproduce the observed results. Using the experimental data and the kinetic model, we give an estimation of the quenching coefficient of N(^{2}P) by N_2.

Finally, two spectroscopic methods were used and validated to measure N(^{4}S) and N(^{2}P) densities. The kinetic method is however limited to measurement inside axisymmetric tube.

Fig. 1: *N(^{4}S) density distribution along the post-discharge tube using kinetic and absolute calibration methods, k_1 is the rate of volume recombination of nitrogen atoms*



Acknowledgments

This research was supported by DGA grant DESDEMONA (RAPID contract)

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