Non-thermal plasma diagnostic using optical emission spectroscopy

D. Astanei[1,2,*], S. Pellerin[2], E. Hnatiuc[1], C. Felea[1], D. Călin[1]

[1] "Gheorghe Asachi" Technical University of Iaşi, Iaşi, Romania
[2] Orleans University /CNRS , GREMI Laboratory – Site of Bourges, France
*Contact e-mail: dastanei@tuiasi.ro

1. Introduction

A complete diagnostic of the non-thermal plasma, considering the temperature, involves the determination of rotational, vibrational and excitation temperature. Next to these parameters, the electron density determination can be also added if the study is following the variation of the plasma parameters as a function of the input parameters such the current values, electrodes shape, control signal type etc.

The aim of this paper is to present a simple manner to apply certain classical in order to determine the plasma parameters indicated above and to exemplify with some results obtained for transient plasma produced by a spark plug.

2. Method description

The presented method supposes the recording of the emission spectra of the plasma using a simply optical setup, composed only from one lens. Thereby the plasma image (or of the part of the plasma channel studied) is focused directly on the spectrometer entrance slit. If the spectrometer used allows it, the function *step-and-glue* should be used in order to obtain spectra with a good resolution and for a higher wavelength range (e.g. 200 to 400 nm). In Fig. 1 a typical N_2 emission spectrum is shown.

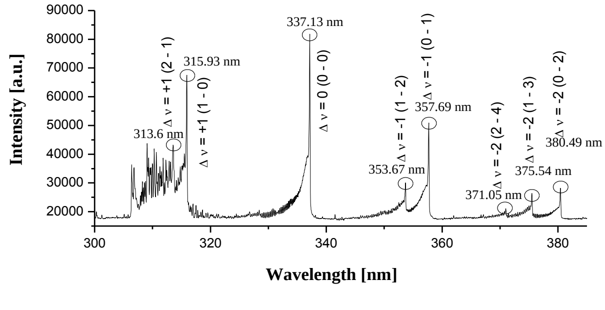

Fig. 1: *Typical N_2 emission spectrum and the transition identification*

In order to simplify the data processing and also to reduce the computation time, the Abel inversion should be performed in order to verify if the plasma channel has a cylindrical symmetry (only if is the case). If the symmetry is confirmed then the spectra recorded from one side is enough for the plasma analysis. The hypotheses made in order to apply the methods are: Boltzmann distribution of the energy levels and local thermodynamic equilibrium.

The determination of the rotational temperature is performed based on the on the OH bands. The method used for the rotational temperature determination is based on a comparison of the emission spectra of UV OH band spectrum at 306.357 nm (see Fig. 2), theoretical and experimental, by identifying the apparatus function $\Delta\lambda_{app}$ of the optical device, [1].

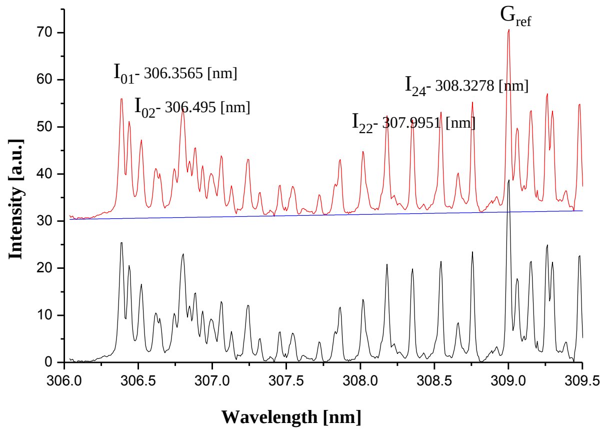

Fig. 2: *Typical UV OH spectrum with the identification of interest peaks and offset extraction.*

For vibrational and excitation temperature determination, the Boltzmann's plot method applied to N_2 transitions (see Fig. 1) and for atomic lines, respectively, is used, [2], [3].

The most common method for electron density estimation is the Stark broadening, [4], which can be applied to different types of atomic lines (Balmer hydrogen series lines, argon, etc.). For the results confirmation it is recommended the utilization of a numerical computation method, such the spectra simulation ones.

References

[1] S. Pellerin, J.-M. Cormier, F. Richard, K. Musiol and J. Chappelle 1996 *J. Phys. D: Appl. Phys.* **29**
[2] B. Hnatiuc, D. Astanei, S. Pellerin, N. Cerqueira, and M. Hnatiuc 2014 *Contributions to Plasma Physics Journal* **54-8** pp 712.
[3] P. Jamroz and W. Zyrnicki 2002 *The European Physical Journal: Applied Physics* **19**, pp. 201
[4] F. Bourg, S. Pellerin, D. Morvan, J. Amouroux and J. Chapelle 2002 *J. Phys. D.: Appl. Phys* **35**, pp. 2281 - 2290, 2002.