Selective emission of a two - spectral lines in a.c. plasmas (M-effect)

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In a number of previously published papers we presented the monochromatization of the noble gas spectra at the addition of hydrogen or oxygen to the noble gas discharges. As plasma source we used before pulsed or even d .c. low power discharge ($2kV$) peak to peak pulsed with the frequencies up to $10-20kHz$. In the case of the present experimental researcher we report the use of increased power with the voltage pulses up to $25kV$ and a frequency of 25 KHz This increased performance will extend the area of gas mixtures in which the M- effect can be established. Even, in present experiment we report the ignition of multiple gas discharges with one wavelength (monochrome) emission l.

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1. Introduction

The Monochromatization effect (M-effect) consists in the emission of a single spectral line of plasmas ignited in certain gas mixtures /1/.

Correlating our experimental results on the M-effect with published data on various types of gas mixture discharges, we also put in evidence the main collision process responsible for the appearance of this effect. A three body collision was found to be the elementary process that generates the monochrome radiation. For a neon-hydrogen mixture discharge, the following three-body equation was found to generate the M-effect:

$$Ne^{+}+H^{-}+H^{*}(n=2)\Rightarrow Ne^{*}(2p^{1})+H+H^{**}(n=3) \qquad (1)$$

where Ne^+ is the neon ion, H^- is the hydrogen negative ion, H^* is the excited hydrogen atom at the level (n=2), $Ne^*(2p_1)$ is the excited neon atom on the neon energy level $2p_1$, H is the hydrogen atom at the ground level and finally H^{**} is the hydrogen atom excited to the level n=3. Dezexcitation of Ne^*results in the emission of the single spectral line observed experimentally.

On calculation of the energy defect of equation (1), a value of 0.1 eV is obtained. The energy defect represents the difference between the energy-states values of the colliding particles on left side and also on the right side of this equation. Thus, equation (1) is energetically resonant.

The energy-state values were taken from references /2-4/. Similar results values of the energy defect were obtained for other electropositive- electronegative gas mixtures also. It was thus proved that the M-effect is due to a resonant recombination of the three body reaction (1).

The main feature of the M-effect is the fact that it can only be obtained in gas mixtures containing at least one electropositive gas and one electronegative gas /5/-/8/. Most experiments undertaken until now involved mixtures of a rare gas with either hydrogen or oxygen.

The current paper reports on new research on the simultaneous appearance of two M-effects in a discharge tube containing two rare gases and an electronegative gas, the hydrogen.

2. Experimental arrangement

The experimental setup used for the study of the simultaneous M-effect is shown schematically in fig. 1. A quartz discharge tube of 16 mm diameter and 200 mm length provided with movable tungsten electrodes was used. The electrodes were electrically insulated using glass, apart from the 20 mm long sharpened ends.

A high voltage power supply of 25 kV and 25 kHz frequency was used. A steady gas flow of different compositions was controlled by flow-meters. The spectra were acquired using a computer-controlled Optical Multichannel Analyzer (OMA).

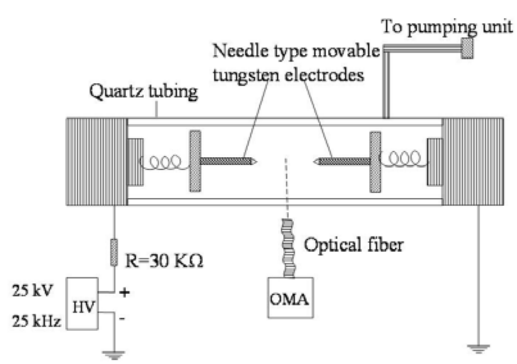

Fig. 1. The experimental device.

3. Results and discussion

A monochrome radiation was obtained in these two-gas mixtures, as presented in Figs. 2.a.2 and 2.b.2.

The wavelengths of the emitted lines are 585.3 nm for the emission spectrum of Ne and 750.4 nm for Ar.

For comparison, the spectral lines of the pure electropositive gases (Argon and Neon) are given in Figs. 2.a.1 and 2.b.1, respectively.

The present paper reports on new studies on the simultaneous emission of two spectral lines using simultaneously two electropositive and one electronegative gas, e.g. Argon + Neon + Hydrogen. In this case, the emitted spectra contained both the emission line of Ne at λ_1 = 585.3 nm and that of Ar at λ_2 = 750.4 nm, as can be observed in Fig. 2.c.2.

4. Conclusions

The M-effect is a powerful effect which gives monochromatic line spectra of wavelengths dependent on the type of gas used. New experiments revealed that this effect can be obtained simultaneously for two different electropositive gases, in the same plasma. In this paper a mixture of Ne and Ar with H_2 was used to demonstrate the existence of this double effect.

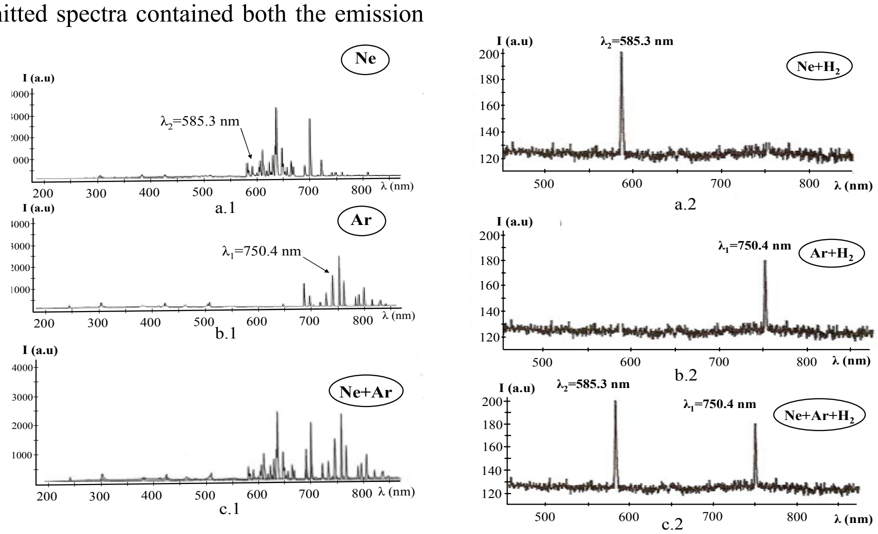

Fig. 2. Emission spectra of a.1 pure Ne, b.1 pure Ar and c.1 Ne + Ar and a.2, b.2, c.2 their mixture with H_2 showing the single M-effect and the double M- effect, respectively.

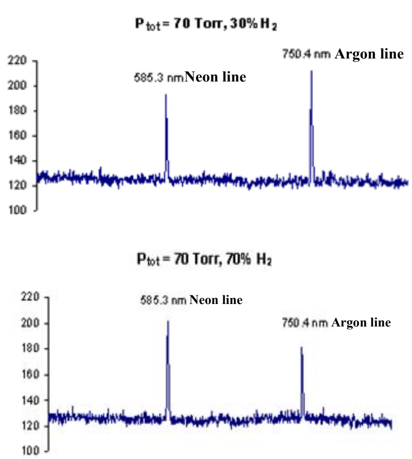

Fig. 3. Spectrum of gas mixtures with addition of H_2 at different pressures.

Further experiments to put in evidence the dependence of the double M-effect on other experimental parameters are envisaged.

The simultaneous emission of multiple lines is the next obvious step of research into the M-effect.

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