

# M – effect generating of two–spectral lines

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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) was first reported more than twenty years ago by a research group from the National Institute for Laser, Plasma and Radiation, Bucharest, Romania. (NILPR) [1].

The M-effect consists in the emission of a single monochrome optical emission line (noncoherent radiation) of a plasma produced in certain conditions inside of a low temperature discharge. To ignite and to maintain such a plasma, a number of conditions must be fulfilled as we will describe later extensively. Thus, one of the main condition given as an example is:

“The M-effect appears when the discharge gas mixture contain at least two gas components, namely one electropozitive gas and one electronegative gas”. [2]

Since the discovery of the above mention gas discharges, M-effect was continuously studied for founding new basic data explaining this effect and also to find out possible applications of the mentioned effect. Other condisions have been also evidentiated along the years, establishing clear and full characterization methods.

As early as 1932, Landau and Zenner [3]-[4] published separately theoretical papers concerning their prediction on enhanced radiation emission of discharge in certain binary electropozitive-electronegative gas mixtures. They predicted the enhanced light emission of the discharge as due to negative ion - positive ion collisional recombination. The main support for the enhancement of the plasma radiation was due to strongly attractive Coulombian forces acting on the oppositely charged ions.

Unfortunately, the number of suitable partners which can be coupled as binary resonant positive ion-negative ions recombination is quite reduced and few papers have been published just on this subject [5].

Due to the intense radiation of the recombination processes taking place at high gas mixture pressure at the scale of atomic and molecular process, a part of

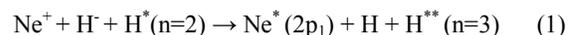
researchers, specialists in this field, devoted their efforts to established the performance of such type of lasers. In the last two decades, intense researches have been concentrated on the excitation of the high pressure gas mixtures (at pressures range of 1 atm – 100 atm) using high energy incident electron beam on gas throught a titanium foil window with a thickness of 25-50 μm. Penning type excitation of atoms and molecules were expected, especially at the upper energy levels of atoms and molecules due to highly energetic electrons. The task was in that time to obtain high power pulsed lasers in over atomspheric gas mixtures.

Limited data (experimental and theoretical) on processes close to M-effect have been found. The closest data to M-effect processes have been reported in the references[6]-[7]. The used gas mixture in this paper was neon and hydrogen. The authors assumed that the reaction taking place in such a plasma is of binary recombination type and the observed laser light has the wavelength  $\lambda=585.3$  nm, the line of neon.

We must point out that according to researches performed at NILPR- Bucharest) along more than decades, the observed effect can be explained by a three body reaction with the following collision partners:

- >  $Ne^+$  - the positive charged neon atom,
- >  $H^-$  - the negative ion of hydrogen atom
- >  $H^*$  - the excited hydrogen atom at energetic level with  $H^*$  ( $n^*=2$ ).

The total energy of the particles after collision is nearly the same with the total energy of particles before reaction. It results an energetically resonant reaction, which fully explain the M-effect, as we will see later. Now, the equation describing M-effect can be written as:



The particles resulting after collision (three body colission) , are:  $Ne^*(2p_1)$  is the neon atom on the excited

state  $2p_1$  in Paschen notation, H is the neutral (ground state) hydrogen atom and  $H^{**}$  ( $n=3$ ) is the excited hydrogen atom on the energy level with  $n=3$  which is decaying to  $n=2$  energy level.[5].

## 2. Experimental arrangement

The experimental equipment used for the study of the M-effect (Monochromatization effect) consists from three main parts, namely the discharge device, the air pumping down equipment followed by the filling system with in advance established gas mixtures at known partial gas pressures and finally, the third part is the a.c. power supply for the generation of the gas discharge device with a high voltage (25kV) pulsed discharge with a frequency of 20 kHz.

To understand how this experimental arrangement is working, we have to enter in details. The discharge device consists mainly from a quartz tubing with an inside diameter of 16 mm and an active length (maximum value) of 100 mm. (Fig. 1). Just on the axes of this quartz tubing there are mounted axially two metallic electrodes which are movable along the axes of the quartz tubing in order to have the possibility to establish various discharge lengths. Therefore, the distance between electrodes can be changed at will using a system with a permanent magnet.

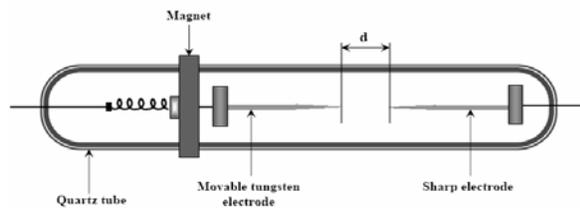


Fig. 1. The discharge device.

In order to help the ignition and also to ensure a stable discharge, the electrodes - made from tungsten wires with  $\Phi=1.5$  mm - are sharpened like a needle. The tungsten wires - except the active electrodes parts - are covered with glass (or a quartz tubing) all along the wire, tightly bounded to the tungsten wire. In this way are reduced the possible spurrious discharges due to the very high value of applied high voltage (25kV).

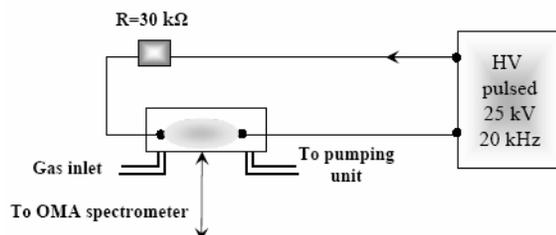


Fig. 2. Electrical set-up of the experiment.

To ignite a discharge in the interelectrode space, the discharge device is filled with a gas mixture of an established composition of the used filling gas mixtures. A pulsed high voltage is applied across the electrodes. A bright light in the gas mixture is established in the interelectrode space, due to the short and powerful applied voltage pulses.

An Optical Multichannel Analyser is mounted perpendicular on quartz glass tubing and on the discharge volume. Using OMA, the discharge spectra is easily recorded. Usually, it is necessary to calibrate the OMA before use but in the case of M-effect the studied emission spectral lines are well known and can be easily identified.

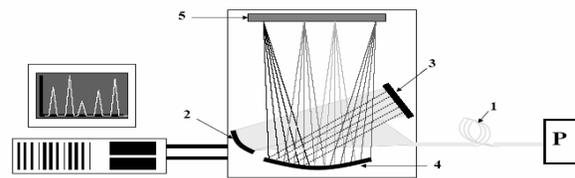


Fig. 3. Schematic diagram of the Optical Multichannel Analyser.

## 3. Results and discussion

A monochrome radiation was obtained in these two gas mixtures, as presented in Fig. 4. The wavelengths of the emitted lines are  $\lambda_1 = 585.3$  nm for the emission spectrum of Ne and  $\lambda_2 = 750.4$  nm for Ar.

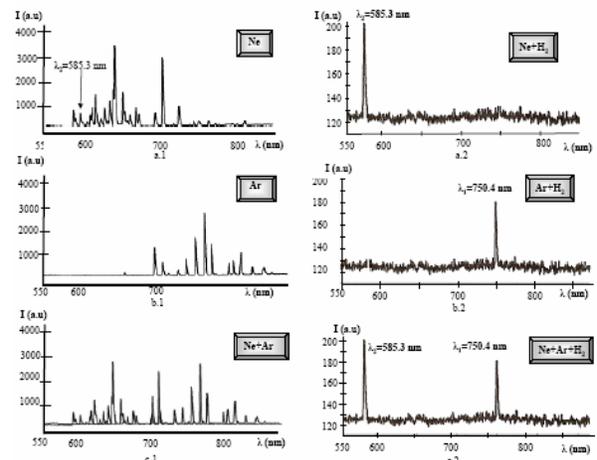


Fig. 4. Emission spectra of a.1 pure Ne, b.1 pure Ar and c.1 Ne + Ar and a.2, b.2, c.2 their mixture with  $H_2$  showing the single M-effect and the double M-effect, respectively.

For comparison, the spectral lines of the pure electropositive gases (Argon and Neon) are given in Figs. 4.a.1 and 4.b.1, respectively.

The present paper reports on new studies on the simultaneous emission of two spectral lines using a mixture of two electropositive and one electronegative gas, e.g. argon, neon and hydrogen, respectively. In this case, the emitted spectra contained both the emission line of Ne at  $\lambda_1 = 585.3$  nm and that of Ar at  $\lambda_2 = 750.4$  nm, as can be observed in Figure 4.c.2.

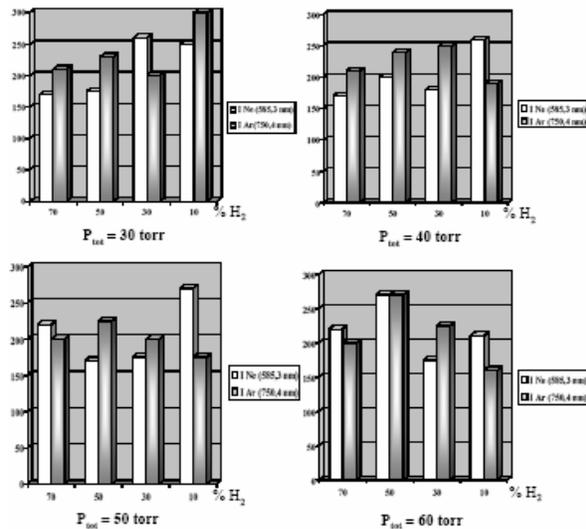


Fig. 5. Comparative graphics of different total pressure ( $P_{tot}$ ) in various percentages of the hydrogen pressure

As can be noticed from the fig. 5, the feature of the double M-effect, namely various dependences, shows that the two simultaneously working M-effect discharges behave like independent phenomena, non interacting close one with other type of atoms.

The dependence is a relatively small, a change of percentages of the two added electropositive gases are behind of a factor of change of 30% while in the real observed diagrams (Fig 5), the changes of the signal (intensity of monochrome radiation) are within 10-15%.

Similar behaviour has been observed concerning the ratio of two monochrome radiations. This result suggests

that the simultaneous M-effect is independent of total gas pressure as long as the relative concentration of the three gases remains unchanged. [8]

#### 4. Conclusions

The M-effect is a powerful effect which gives monochromatic line spectra of wavelengths depending 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.

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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