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Oscillatory Properties of Subnormal Glow Discharge in Longitudinal Magnetic Field in Air

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ABSTRACT

The oscillatory properties of subnormal glow discharge have been studied by Jana and Pradhan in longitudinal magnetic field for inert gas argon [4]. The aim of this paper is to investigate the validity of the variation of these oscillatory properties studied in longitudinal magnetic field in a mixture of gases, air. The oscillograms of current-pulses have been presented. The variation of frequency, bandwidth, peak-peak voltage and rise-time have been studied and it is found that the frequency, bandwidth, rise-time and cut-off current increase but peak-peak voltage decrease with the increase in magnetic field. The power spectrum of ionization fluctuation is also studied. It increases with the increases in magnetic field. This investigation shows the exact validity in the result of the variation of oscillatory properties in air with that in argon.

Keywords: Subnormal glow, oscillatory properties, current-pulses, power spectrum.

1. Introduction

The discharge region between Townsend discharge and normal glow discharge is the subnormal glow discharge region. This region shows negative resistance [1]. The characteristic properties of this region have been studied in transverse and longitudinal magnetic fields earlier [5-8]. This subnormal region has also oscillatory properties [2-3]. This region generates current pulses. The oscillatory properties in transverse magnetic field have been studied earlier [9]. The present work is the investigation on the variation of oscillatory properties of the subnormal glow discharge with longitudinal magnetic field using a mixed gas, air and to search the validity of the nature of variation of current pulses with the same in argon. In this case the gas pressure and average tube current remain constant. It is observed that the frequency, bandwidth and rise-time of current pulses increase with the increase in magnetic field but the peak-peak voltage decreases. The cut-off current and power spectrum of ionization fluctuation are also studied. These variations are in the full agreement with the results obtained in the gas argon. So the variation of current pulses in all types of gases with longitudinal magnetic field is equally valid.

2. Experimental arrangement

The experimental arrangement for the present work is made as shown in the Figure 1.

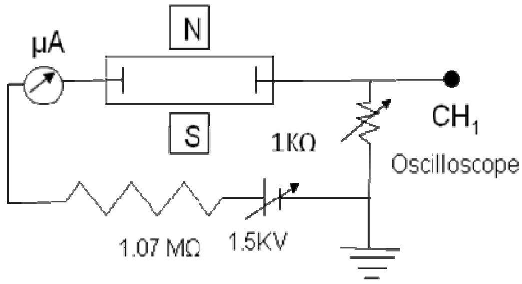

Figure 1: Experimental set-up

The discharge tube is cylindrical and made of pyrex glass and it is of length 6 cm, inner diameter 4.8 cm, fitted with two plane parallel circular copper electrodes of diameter 4 cm separated by a distance 1.8 cm. The tube is thoroughly cleaned and dried. The discharge tube was exited by a variable dc voltage source (with insignificant ripples) of the capacity up to 1.5 KV. The ballast resistor of 1.0 MΩ limits the discharge current and keeps the high voltage unit within its current capacity. A current-meter (sensitivity:±0.25) was connected in series with discharge tube to record the average tube current and cut-off current in the circuit. A micro-leak needle valve is connected with the discharge tube to control the gas pressure within the tube. The pressure of the gas was measured by a Mcleod gauge (sensitivity: 0.05 torr). The magnetic field was produced by an electromagnet energized by a stabilized power supply. The magnetic field was measured by an accurately calibrated gauss meter (sensitivity:2%). The tube was excited at a constant low pressure and longitudinal magnetic is varied keeping the average tube current constant. An oscilloscope (CH_1) is connected across the pot. divider (1 kΩ) and oscillograms are taken by it in different magnetic fields. The frequency, bandwidth, peak-peak voltage and rise-time are measured.

3. Results and discussion

The subnormal discharge consists of current pulses or a number of oscillations. The system for the measurement of the oscillation parameters is shown in Figure-1. The oscillograms of current pulses for the variation of longitudinal magnetic field between 0 and 1850 G at fixed pressure 0.35 torr and constant average tube current 30 µA have been exhibited in figure-2.

It is observed that the frequency, bandwidth, as well as rise-time increases with the increase in longitudinal magnetic field but the peak-peak voltage of current pulses decreases. The results are shown in Table-1 for a constant current 50 µA.

In longitudinal magnetic field the axial electric field and electron temperature decrease whereas the radial electron density increases and the discharge current gradually increases in magnetic field finally saturates. The mobility of positive ions increases under the action of longitudinal magnetic field for fixed voltage. Therefore, the transit time of current pulses decreases and the frequency increases. Consequently, the variation in all other parameters takes place. The variations of frequency with magnetic field for different tube currents at constant pressure 0.35 torr have been studied and it is shown in figure-3. It shows that the frequency increases with average tube current at constant pressure and magnetic field.

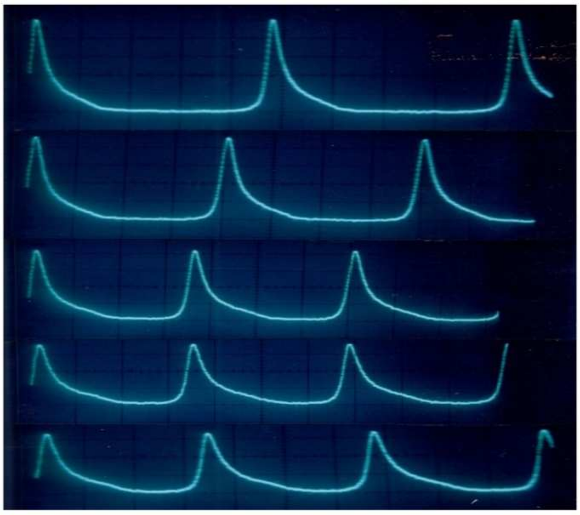

Figure 2: Oscillograms of current pulses with magnetic field (from up to down) H=0G, 738G, 1097G, 1480G, 1850G. The same base (25µs/div.) and sensitivity (0.1V/div.), Pressure: 0.35 torr, Current: 30 µA.

Table 1: Data of oscillation parameters with magnetic field

Pressure in torr	Average tube current in µA	Magnetic field in G	Frequency in kHz	Peak-peak voltage in mV	Rise-time in µs	Bandwidth in µs
0.5	75	0	16.33	736	2.8	4.8
		150	17.3	624	3.2	5.1
		300	19.8	576	3.4	5.4
		450	20.1	472	3.6	5.8
		600	21.5	416	3.8	6.4

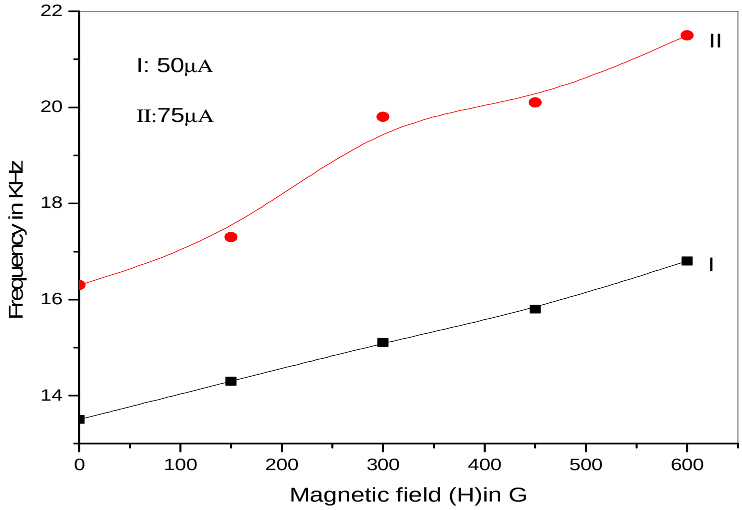

Figure 3: Variations of frequency with magnetic field at pressure 0.35 torr

Figure-4 shows the change of cut-off current with magnetic field at constant pressures 0.5torr and 0.6 torr on fundamental modes. The nature of the curves are almost same for these pressures gradually rising up to the maxima and then falling down and finally tending to saturation with the magnetic field and the saturation shifts to a higher magnetic field as the pressure increases.

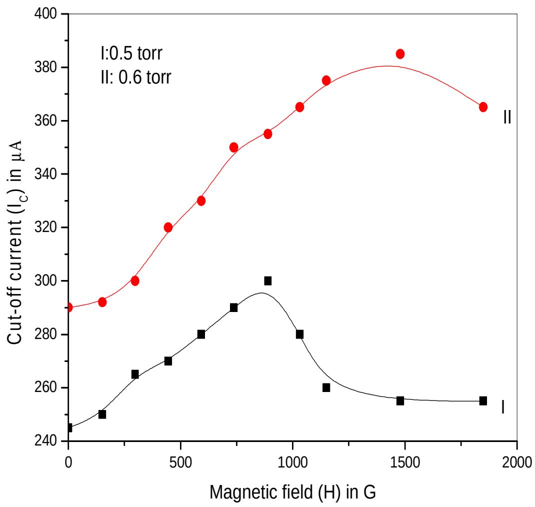

Figure 4: Variation of cut-off current with magnetic field (0G -1850 G) at constant pressure (P): I: 0.5torr, II: 0.6torr

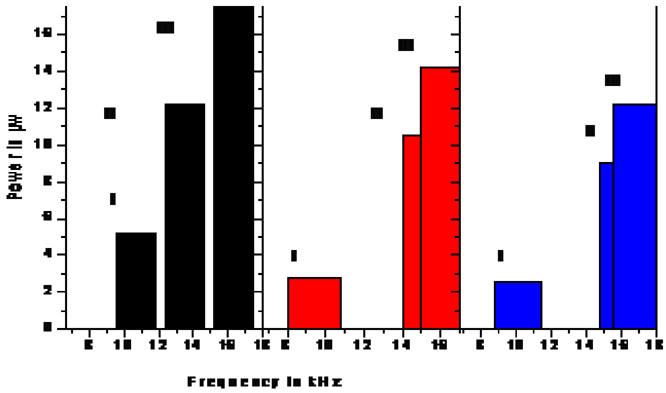

Figure -5: Power spectra of ionisation fluctuation at P = 0.6 torr and I: H=0G, II: H= 150G, III: H= 300G

Figure-5 shows the power spectrum ionization with frequency of the current pulses which appeared with magnetic field off and on at pressure 0.6 torr. The mechanism for the production of pulses involves rapid ionization in the cathode region and the formation of a steep potential gradient relative to the positive column. The velocities of the positive ions change as they cross the negative glow while entering the cathode dark space. Therefore fluctuations in the discharge current occur with a frequency corresponding to the total time involved in the process which largely depends on the movement and collision of positive ions. When the current is increased the waveform changes gradually and at the same time the period of the fundamental modes changes. The corresponding frequency varies with VI (power) or I, since in the region under consideration the product of VI is a linear function of I.

4. Conclusion

It is observed that the oscillatory properties of subnormal glow discharge show exactly the same qualitative variation with longitudinal magnetic field in a gas mixture. The frequency, bandwidth and rise-time of current pulses increase with the increase in magnetic field but the peak-peak voltage decreases in air. The cut-off current and power spectrum of ionization fluctuation are also studied. All these investigations point out the full agreement of the results obtained in this case with that in argon. So the variations of current pulses with longitudinal magnetic field in all types of gases are equally valid and satisfied.

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