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EFFECT OF MAGNETIC FIELD ON PLASMA ION DENSITY

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Abstract: Research in plasma physics field. we study the effect of magnetic flux density ion (0.05-0.1)T plasma column, the result from this that the increasing of the magnetic which increased plasma ion density. Also, we studied larmor radius and cyclotron frequency and drift velocity and ion density in present the magnetic field We find a decrease in the velocity of the plasma ion when the flux increases due to the inverse proportionality and collisions between the electrons and also a decrease in the Larmor radius due to the inverse proportional it and the proportionality is direct between the cyclotron frequency and the magnetic flu. as the density of ions increases with the increase in the magnetic flux because the movement of the ions Under the influence of the magnetic field, it is spiral, so the plasma ion density increases.

1.1 Introduction

Plasma is a fourth states of matter, the others being solid, liquid, and gas. Plasma has properties unlike those of the other states. Plasma consists of electrons, ions and atoms that are neutral under certain conditions. Plasma is a quasineutral gas of charged and neutral particles which exhibits collective behavior. Quasineutral means that the ionized gas with equal concentration of positive and negative charges and neutral species. Furthermore, the collective behavior we mean motions that depend not only on local conditions but on the state of the plasma in remote regions as well [1]. When the temperature is hot enough. Balance between collisional ionization and recombination [2]

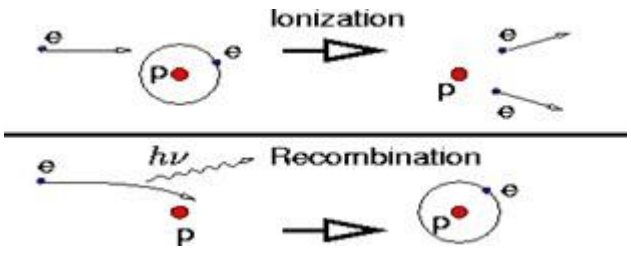


Fig.1.1 Ionization and Recombination [2]

The presence of a significant number of charge carriers makes plasma electrically conductive so that it responds strongly to electromagnetic fields.

By using directly or indirectly heated of surface (or tungsten filament using high electric current) are mainly used to generate thermo ionic electron which are accelerated to elevated energies to ionize the gaseous media with magnetic fields 0.01-0.02 T [2,3] The discharge is initiated and sustained by microwave

induced excitation and microwave generator is 2.45 GHz, which is effective in producing a high plasma densities of up to 10^{13} cm [3, 5].

In this method an intense of a pulse laser beam injected in an under dense plasma excites an electrostatic wake behind the laser beam. The beam of laser sets the electrons due to the space charge produced by displacement pulls the electron back and plasma oscillation is set up the trapped electrons can given a large amount of energy, and this can increase the ion density in the plasma [6].

In a cold gas such collisions are very infrequent, in a hot gas more likely.From the Maxwellian velocity distribution function we can derive the Saha equation which gives the fraction of ionization we can expect in a gas in thermal equilibrium at temperature T,[1]

There are different kinds for dense plasma applications, such as, industry (coating, drilling and heating), communication device and in space, Sterilization, and Etching of components[7]. Theoretical and experimental are carried out for studying the effects of magnetic flux in enhancement and obtain dens plasma. In 1979 Sidenius [8] is analyzed the fundamental features and characteristic ofdischarge and plasma ion source. The effective of magnetic flux on the discharge gases was studied. In 1986 Toshiro et al. [9] has been studied the effects of magnetic flux on ion energy during etching is controlled by utilizing the interaction between the electron cyclotron resonance. In **1992** M. Dropmann et al. [10] are studied the interaction between a magnetic field and plasma close to a nonconductive surface is of interest for both science and technology. In **2001** Kazuo Koike and Norifumi Ono [11]An experimental study of plasma jet at a low pressure was carried out to examine the influence of strong magnetic field on the temperature distribution. This is a fundamental. Study of the possibility that the jet can be controlled by the strong magnetic field. In **2004** Michael Keidar and Jochen Schein [3], The hydrodynamic model ofthe vacuum arc thruster and its plume is developed. Primarily an effect of the magnetic field on the plume expansion and thruster operational conditions is considered. It was found that magnetic field significantly decreases plasma plume expansion, while on the other hand causes arc voltage increase. In **2005** Valery Godyak and OSRAM Sylvania [12]A numerical study ofthe fluid model for a cylindrical weakly ionized quasi-neutral plasma in an axialmagnetic field is presented. The model takes into account inertia, ionization andfrictional forces for ions and electrons for arbitrary magnitudes of the axial magnetic field. In **2014** Pillaca et al.[13] are A comparison between experimental measurements and numerical calculations of the ion current distribution in plasma immersion ion implantation (PIII) with external magnetic field is presented. Later, Silicon samples were implanted with nitrogen ion to on them. The magnetic field considered is essentially non-uniform and is generated by two magnetic coils installed on vacuum chamber. In **2014** Sang Chao-Feng [14] has been stydied, a kinetic model is used to study the de-pendence of the H penetration depth inside the poloidal gaps of plasma-facing components on operation parameters. It is found that the penetration depth of H decreases with the magnetic field strength **B** increasing, and increases with th plasma temperature $\mathbf{T_e}$ rising. In **2015** L A Ladino et al.[15] studied the Motion of a charged particle in aconstant and uniform electromagnetic field. In **2016** Masoomeh et.al [16] was studied the effect the effect of magneticfield in plasma with laser pulse. The results show these effects on increasing ion density.In **2019** Mariammal et al. [17] an experimental investigations to study the accumulation of ions and diffused electrons along with the associated non-linear behaviour brought about by the plasma bubble in a magnetized, filamentary discharge plasma.. It have also verified the experimentally observed potential structure using numerical analysis based on fluid hydrodynamics and found that they agree with each other.In **2022** Munish et al. [18] studied the density gradient of plasma in magneticfield and its effects on electron temperature**. This study is aims to** studying the effect of external magnetic field on plasma ion density

2. Methodology

2.1 Introduction

In this chapter, the basic equations which deles of interaction magnetic fieldand plasma will be discussed.

2.2 Motion of charged particles in magnetic fields

If we applied a magnetic flux density **B** on the charged particle, then the particle taking a circular trace around the line of magnetic field.

By using Lorenz force

3. Results and discussion

3.1 Model under study

The consideration model is consists of two circular cathode and anode electrodes. The plasma argon gas is confined by applying external magnetic.

3.2 Computation program

A computation program written in Fortran language for calculating plasma parameters with different values of magnetic flux density by using a software Fortran power station V4 for compiling linking and exacting the program.Appendix (A), shows that the flow chart for program.

3.3 Input data for computation program

By using the input data in **Table 3.1** and the equations in chapter two the ion density and other plasma parameters is calculated under the effect of magneticflux.

Table 3.1 Input data for computation program

n_o	$1x10^{6}\ m^{-3}$
m_{Ar}	$6.65x10^{-26}$ kg
m_e	$9.1x10^{-31}$ kg
q	$1.6x10^{-19}$ C
d	$6.0x10^{-2}$ m
r	$4.0x10^{-2}$ m
ν_i	$4.0x10^{6}$ Hz
f	$1.0x10^{4}$ Hz
V	200 volt
B	0.05 -0.09 T

3.4 Effect of magnetic flux on drift velocity

By using data in **Table 3.1** in computation program, the effects of magneticflux density with values (0.05-0.1T) on drift velocities v_d are studied. It is noticed that the values of drift velocities decreases as the magnetic flux increases as show in **Fig. 3-2**. Because the magnetic flux is proportional inversely with the drift velocity as in **Eq.2.5** also because of collisions which happen between the electrons.

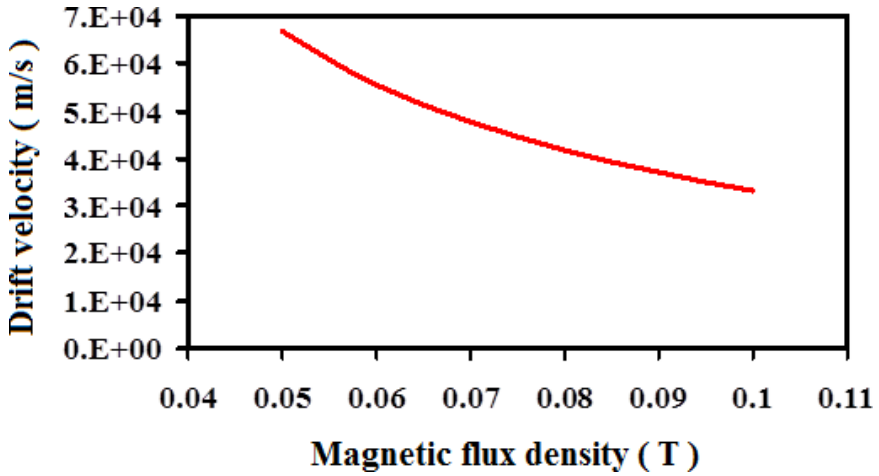


Fig. 3.1 Drift velocity as a function of magnetic flux density.

3.5 Effect of magnetic flux on the larmor radius

The values of Larmor radius are decreased as the flux of magnetic flux densityincreased as show in **Fig 3.3**

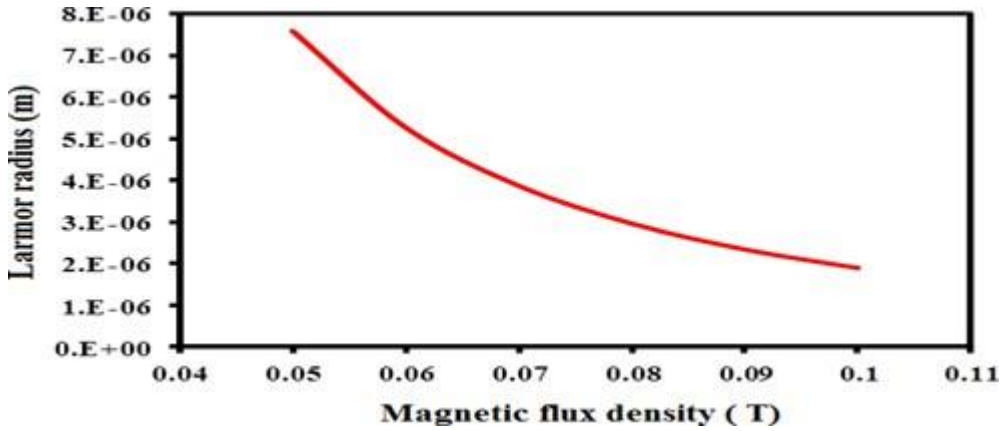


Fig. 3.2 Larmor radius as a function of magnetic flux density.

Because the magnetic flux is proportional inversely with the larmor radius as in **Eq.2.3** and when the electron round under the affect of the magnetic felid the radius (larmor radius) is decrease.

3.6 Effect of magnetic flux on the Larmor cyclotron frequency

The values of cyclotron frequencies are increased as the flux of magnetic fieldincreased as show in **Fig. 3.6**

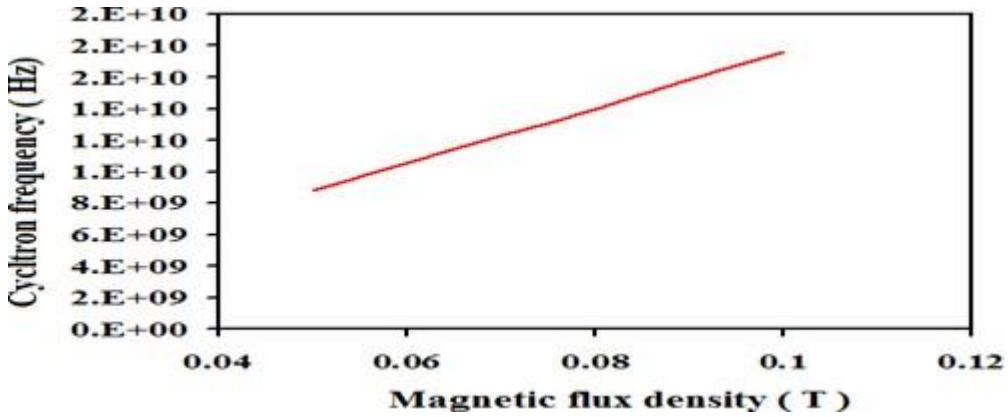


Fig. 3.3 Cyclotron frequency **as a function of magnetic flux density**

3.7 Effect of magnetic flux on the ion density

The effects of magnetic flux density on argon ion density using the boundary condition and **Eq.2.14** to **Eq.2.17** in computation program are studied. The values of ion densities are increased as the density flux of magnetic increased as show in **Fig.3.4**. because of the path of the electrons under the effect of magnetic felid is look like helical.

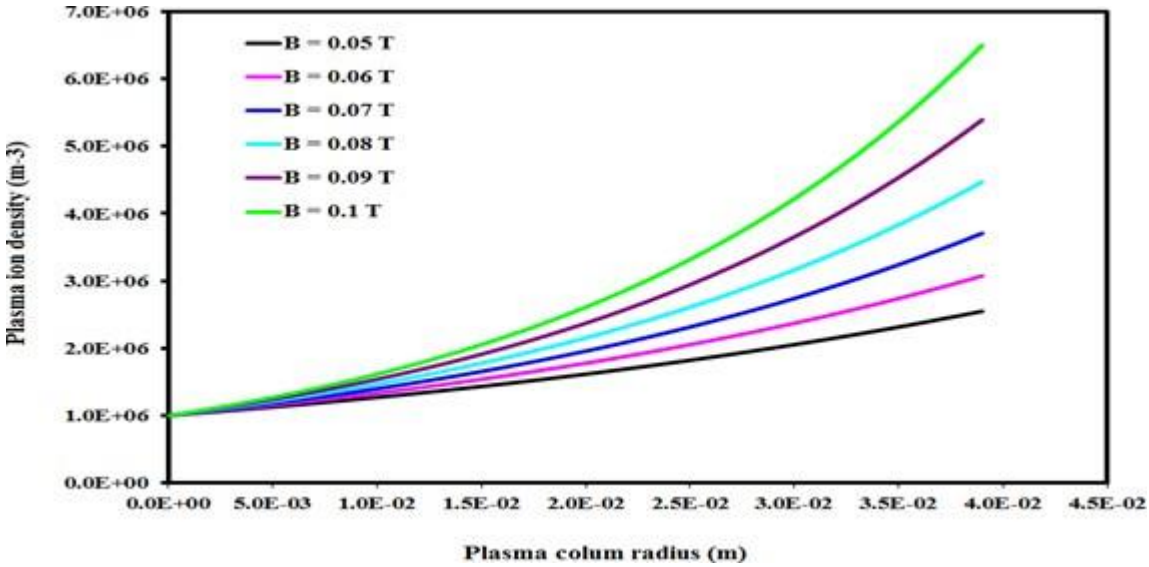


Fig. 3.4 Argon ion density as a function of magnetic flux density**.**

Conclusions

It is clear from the results of this study the important of magnetic flux densityon the plasma parameters. The interaction of magnetic flux caused to increased the argon ion density. This increase of density can used to reduce the gas pressure in plasma source and obtained dens plasma in different applications.

Future works

There are many future works are required to achieve further details for using magnetic flux density in plasma such as,

1. The effect of non uniform magnetic flux density.
2. Calculation of ion density with different values of electron temperature.

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