Split and observing the spin of free electrons in action

Plasma theory and Stern-Gerlach experiment by free electron in Quantum theory*

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In this article some observed objects in the experiment and the way of compatibility classical relationships between empirical observations from the view points of the plasma physics have been investigated, the plasma physics equations rooted in classical physics and quantum mechanics equations; given that the possibility of separation and direct observation the spin of free electron is one of the most discussable issues in the quantum philosophy during the last few decades, this paper has been studied some of technical and scientific issues of the experiment.

I. INTRODUCTION

Considering the highly importance of Stern-Gerlach experiment with the spin of free electrons and questions and ambiguities which may be created in the readers minds, it is necessary to present a detailed explanation of this experiment; therefore, first, theoretical and classic issues about Stern-Gerlach with the spin of free electrons have been studied and then some problems about plasma and oscillations in the plasma and fields (electric and magnetic) and their conditions and the Maxwell distribution have been examined and in following the impacts of thermal contact and movement and dispersion and waves and the equations of the movement in the plasma, Probe Langmuir, evaluation of the electrons speed in action have been examined and finally, the developing and knowing the used components in the experiment have been investigated.

II. NOTES OF CLASSICAL PHYSICS THEORY

Undoubtedly, Stern-Gerlach experiment is one of the most important experiments in the period of classical quantum mechanics. The basis of this experiment turned to the most fundamental principles of the quantum mechanics and it is on the most challenging issues. Since, Samuel Goudsmit,George UhlenbeckWolfgang Pauli in 19^{th} century suggested the theory of Spin for microscopic particles such as electrons for the first time,this theory used principle a basic concepts for describing the way of elementary principals behavior that its origin should be sought in the quantum and Newtonian mechanics because each theory is supplement of the old theories.

Assume an elementary and very small particle as a sphere which is consistently that turns around and it is impossible to judge about its circulation at all, an angular momentum can be attributed to this object which its magnitude and its radius depend on linear momentum. If the radius of the particle limited to zero you have a very microscopic particle, for example the mass of electron and radius is $m_e = 9.11 \times 10^{-31}[kg]$ & $r_e = 2.8179 \times 10^{-15}[m]$

considering the moment of inertia for ideal sphere it is possible to achieve the electrons circulation frequency, certainly, obtained magnetic moment would be as $\mu = \frac{e}{5}\omega r_e^2$ considering the very small radius of electron,the electron speed is estimated more than light speed that is in a clear contradiction with special concepts of relatively.

However, adjustment and reduction of this speed could be result from several reasons, for example your imagination about the general term of electron can be contain of many smaller particles with different momentum and in different directions which lead to decrease the momentum and etc. one of the quantum mechanics qualities is that you knowledge of them is not certain and the particles path is not specific and localization is not distinguished.

Therefore the higher information about location of the particle is lesser about the particle momentum. Attention that the concept particles Spin in quantum physics is different with your knowledge about the concept in the classical mechanics.

The magnitude of the angular momentum in definition of the classical mechanics is as $L = r \times p$ but in the quantum mechanics the magnitude of angular momentum is defined using quantized magnitudes. Notice that the spin is a intrinsic concept in the quantum for microscopic elementary particle and this regulations is based on quantum mechanics and there is no classical equivalent for it. If the direction of the angular momentum is limited to a specific direction for example toward the axis Z, L_z the vector of angular momentum only can have specific magnitudes; it has been known as Space quantization. The relation of angular momentum can be write in a limited space for microscopic spin particles

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* ***Patent:*** *Electron Intrinsic Spin Analyzer,*
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Patent Link: Ref[27]

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$S_z = m_L\hbar, (m_s = -s, -s+1, ..., s-1, s)$, all particles dont have same spins number in the nature,some of spins coefficient particle is $\frac{1}{2}$ and another spins coefficient particle is not $\frac{1}{2}$,Just two quantized magnitudes can be considered for angular momentum (natural spin) for the elementary principal of electron $S_z = \pm\frac{1}{2}\hbar$ It means that the electrons just could rotate in two directions, clockwise or anti clockwise rotations,that this natural circulation lead to small dipole moment. Thus, in a spinories system including different particles with different spins, the separation of these natural qualities should be possible.

When the spin theory was considered the main problem for the possibility of separation the spin of free electrons until now, but it confronted with theoretical problem and challenges problem. The main challenge was that because the electron and other small particles have a little mass, then the calculation of classical physics has a problem of incompatibility in calculations.

For example, consider a free electron that in 1 $[kv]$ potential differences and in this case energy changes of the entire particle is $E_{Total} = U + T$ With regardless of the energy changes, wastes and thermal effects it is expected that all the potential electrical energy transform to kinetic energy, therefore the linear speed of electron will be achieved .TableIII,IV ,TableIII

$$\frac{e}{m_e} \cong 1.75 \times 10^{11} \left[\frac{C}{kg}\right] \tag{1}$$

$$v_x \cong 10^7 \left[\frac{m}{s}\right] \tag{2}$$

Considering the needed force for separating the spin of the electrons and the time of interactions

$$F_s = \mu_b.\nabla B \quad [N] \tag{3}$$

and

$$t = \frac{l}{v} \quad [sec] \tag{4}$$

will have a classical momentum

$$\triangle Z = \frac{1}{2}at^2 = \frac{1}{2}\left(\frac{\mu_B}{m_e}\right)\nabla B\left(\frac{l}{v}\right)^2 [m] \tag{5}$$

$$\frac{\mu_B}{m_e} \cong 10^7 \left[\frac{j}{T.Kg} = \frac{m}{S^2.T}\right] \tag{6}$$

in consequence the gradient magnetic field will be obtained as simple as following:

$$\nabla B = \frac{2\times\ \triangle Z \times v^2}{10^7 \times l^2} \qquad \left[\frac{T}{m}\right] \tag{7}$$

now consider this example for a spinal separation from 1 micrometer to 10 micrometer level, because this magnitude of separation can be easily observable in the laboratory and observation is possible using available instruments. Moreover, consider for length of magnets is 25 cm, then the relation of gradient magnetic field is as

$$\nabla B \approx \frac{2\times 10^{-6}}{0.0625\times 10^7} \times v^2 \qquad \left[\frac{T}{m}\right] \tag{8}$$

and based on the range of free electrons speed that predicted the relations of classical physic Ref[2] for medium and routin voltages (from 300 $[volt]$ to 30 $[kvolt]$) the electrons speed, which is clear in level $\approx 10^7 \quad \left[\frac{m}{\text{s}}\right]$ to $\approx 10^8 \quad \left[\frac{m}{\text{s}}\right]$ that the gradient magnetic field must be about $\approx 320 \quad \left[\frac{T}{\text{m}}\right]$ to $\approx 3200 \quad \left[\frac{T}{\text{m}}\right]$ This is obvious that for observing the mentioned phenomena with free electrons, an extremely high gradient is required for seperating the spin of free electrons and in a very ideal situation.

In the other hand, another main problem is the mass of electrons,it is very low and leading to its high effectiveness in action against external magnetic fields. so that with a little order of Lorance forces you can not observe and seprate the spin of free electrons, deviation of classical calculation is clearly.The best scientist and theoretician is Bohr ,he said about it that:

"It is impossible to observe the spin of the electron, separated fully from its orbital momentum, by means of experiments based on the concept of classical particle trajectories". Ref[3]

From that time to present time, Scientist have been a lot of debates about possibility of direct observing the spin of free electrons in action. But different presented strategies in this context based by Bohr and Pauli did not lead to the observation of this phenomenon until the article was published Ref[1]. Interested to study these series of quantum philosophy and debates can refer to collected series of Zurek and Wheeler.Ref[4] The results of Pauli and Bohrs discussing with disagrees is that their strong reasons reject the possibility of observation.Ref[5]. However, this charm has been break by WKB method in the quantum mechanics theory. Ref[6]. Although, most of recommendations in this field have been condemned to failure using their reason, Bohrs suggestions allowed to arguments that observing this phenomenon is possible by the spectrum of atomic bands that makes observing this phenomenon indirectly.

Therefore, by helping the Space quantize theory, explored previously by Bohr and Zomerfeild, Stern and Gerlach used existed symmetry silver atoms and designed an experiment.Ref[1],[10] You know that the silver atom has 47 electrons in all bands

$$^{108}_{47}Ag \ \ : [Kr] \ \ 4d^{10}, 5s^1 \tag{9}$$

and its 46 electrons together have an electeric cloud with pure angular momentum zero with sphere symmetry, therefore atoms angular momentum only results from the last electron of the axis. Hence, the electrons of silver atom when exposed to inhomogeneous magnetic field will be separated with respect to the momentum resulting from small and natural moment last electron of the axis.

Stern and Gerlachs innovative solution using free electrons just could show separation of spin free electrons in the atoms band, but by using a mediator atom it is indicated that the fact of natural spin is undeniable and it is not just a theory.

III. PLASMA

In a plasma , ions and electrons forming plasma are equal to charges and currents. Plasma cannot be considered as a magnetic environment. Because particles move in plasma complex. In physics, plasma usually uses Maxwell equation in vacuum in which σ and j include all external charges and currents $j = n_i q_i v_i + n_e q_e v_e$,and $\sigma = n_i q_i + n_e q_e$ plasma acts as fluids and sometimes as set of single particles. But, due to collective behavior , they dont tend to follow external effects. One of the main properties of plasma behavior is its ability to remove electeric potential affecting . Where potential energy is high , there is low particles , because all particles dont have enough energy to reach there. The criterion of the environment to be plasma is the magnitude of its density so that the Debye length λ_d is lower than l dimensions of system.

To consider an environment as plasma environment , it must satisfy three characteristics of plasma environment

$$\lambda_d \ll l; N_d \gg 1; \omega_\tau > 1 \tag{10}$$

Plasma can be identified by two main parameters n and KT_e . plasma density may be$\approx 10^{12}$couples of electron-ion in cm^3. quasi-neutral plasma approximate is $n_i \approx n_e \approx n$ enough to be supposed$n$.In a same time , plasma can have several temperatures , and degree of ionization in plasma remains low by increasing temperature until U is multifold of KT. In an environment, whatever temperature increases the density of neutral atoms becomes less than density of ionized atoms.

Plasma relations show $\frac{n_i}{n_n} \approx 2.4 \times 10^{21} \ \frac{T^{\frac{3}{2}}}{n_i} e^{-\ \frac{u_i}{KT}}$ that ionic density of equilibrium state must decrease by n_i. Most of laboratory plasma have temperatures of one million Kelvin , but it is not serious in low densities of wells heating. Plasma particles tend to decrease magnetic field and plasmas are diamagnetic. Plasma tends to be neutral. To deviate from complete neutral , it adjusts itself so that there is enough charge to form equilibrium of electrons forces affecting. Charges act in plasma so that Poisson equation satisfies. If it is supposed that $n_i = n_e$ and $\nabla . E \neq 0$, plasma approximation is used to mention wave motions. Plasma approximation is valid for all waves other than waves with very low wavelength. If one type of particles can moves and another one cannot move , the plasma approximation will not be valid and electeric field must be found from Maxwell equations (not ion-electron motion equations). In plasma fluid approximation , plasma can consist of two or more fluids which are combined with each other that each of them is related to one type of forming particles.

If Kv_0 have enough magnitude , natural frequency on fluctuations in electeric fluids ω_P and ionic fluid $\Omega_P = \sqrt{\frac{m}{M}}\omega_P$ can converge each other and fluctuations can satisfy in Poisson equation. Plasma frequency depends on plasma density and is one of the main parameters of plasma. Due to small mass of plasma frequency usually is very big. When plasma density changes , passing through plasma causes density to drop ,which make frequency of combined fluctuation equal to exerted frequency. This is because high combined fluctuations are excited and are absorbed from beam of energy.

However real plasma has density gradient and plasma tends to scattered toward low density. Complete ionized plasma behavior differs from ionized plasma. In weak ionized plasma , $v_e = -\mu_e E$ and $j = -nev_e$ a part that $j = ne\mu_e E$, because it only depends on neutral density , current is dependent to plasma density. in plasma , momentum is transferred through electromagnetic forces in complex way . plasma expands as a results of pressure gradient and forces of electeric field. If plasma frequency is equal to cyclotron frequency , particles are not effectively transferred across the magnetic field. Refractive index of plasma environment which is considered as scattered one changes by changing plasma frequency. Plasma acts as a convex lenses and makes the beam in lower diameter.

IV. FLUCTUATIONS IN PLASMA

Wave in plasma is formed by moving all beams with each other . if density is small enough ,(number of beams becomes big enough) , particle must be corresponding fluctuation in density so that the current become constant. When fluctuation begins , the object averagely neither obtain energy nor lose it. If charged particles are exposed to a magnetic field , it begins to fluctuate. Frequency of this fluctuation called cyclotron frequency is defined as $\omega_c = \frac{|q|B}{m}$. rotator centre of this fluctuation has beam called Larmor beam and is defined as $r_l = \frac{v_\perp}{\omega_c} = \frac{mv_\perp}{|q|B}$.

Rotation direction is in such way that charged particle -produced magnetic field is opposite to external field. particle beam has lower r_l for particles with same velocity and different mass ; as a result, it finds less driving. To particles with same mass and different energies have same ω_c. slower particle has less Lamor beam ;as a result, it obtains less energy from electeric field in each half rotation. But for low energy particles, particle change of Larmor beam is bigger for a given change of energy and these two effects neutralize each other.

If plasma environment is ready so that density becomes constant along each path , particles neither obtains energy nor losses it. Even in fluid discussion, waves can interact. Each cyclical motion of a fluid can be disintegrated by Fourier analysis with different frequenciesω and different wavelengths λ.

The speed of wave phase in plasma is higher than beam velocity. This rejects special theory of relativity , because a group of infinite wave with constant range can not carry information. Module information does not move with phase speed but it is carried by group speed which constantly is lower than beam velocity.

Total of two waves with same frequencies cause pulse , wave push carries information. This push moves by$\frac{\triangle\omega}{\triangle K}$ speed. Group speed cannot be more than beam velocity.$v_g = \frac{d\omega}{dK}$. If electrons velocity in a plasma are transferred inhomogeneous ionic distribution, electeric field will exist in the direction returning plasma neutrality by transferring electrons to their primary places.

Electrons move forward due to inertia and make fluctuations with given frequency of plasma frequency around their equilibrium places. This fluctuation is so fast that heavy ions dont have chance to respond fluctuating field and they can be considered constant. Accumulation of charge forms cyclical spatial field of electeric field which tends to return electrons to their neutral place.

In fluctuation of plasma electrostatic , plasma frequency is ω_p . electrostatic fluctuations dont need the existence of magnetic field. Ions with monotonic distribution are in the space. In plasma fluctuations, electeric motions only occur in direction of an axle. If fluctuation occurs in plasma, it must have frequency which only depends on n , and it does not depend on K. plasma fluctuations do not occur in direction of propagation.

Plasma fluctuations don't occur towards propagation. Plasma fluctuations only become bigger when magnetic field are vertical to propagation direction.

$\omega^2 = {\omega_p}^2 + \frac{3}{2}K^2 {v_{th}}^2$

If electrons of beam accumulate so that it passes each given point with f_p frequency, they produce an electeric field with same frequency. It is not necessary to form electric charge groups before forming plasma fluctuations; as soon as they are produced, they cluster the electrons and fluctuations will grow with positive feedback. Sound waves are pressure waves that scattered by collisions among air molecules from one layer to another. In plasma without neutral particles and low collisions, same phenomenon occurs. This is called ionic acoustic waves or ionic wave.

Acoustic waves cannot exist through mediate electeric field. Because there is heavy ions motion and low frequency fluctuations and you can use plasma approximation but you cannot use Poisson equation. Plasma fluctuations mainly are single frequency waves and are related to thermal motions by modifying. Ionic waves mainly are ones with constant velocity. They only exist when there is thermal motion. For ionic waves, group speed is equal to phase speed.

Ions like usual sound waves form diluted and dense regions. Density regions tend to extent to diluted regions for two reasons:

1) thermal motion scatters,

2) ionic groups have positive charge.

And due to obtained electeric field, they tend to scatter. Electrons make shield against field and there is minority appropriate to KT_e so that they act on electrons groups. Due to being inertia ions move and form dense and diluted regions again.

When KT is 0, there are ion waves again. This phenomenon does not occur in neutral gass $v_s = \sqrt{\frac{KT_e}{M}}$, this often occurs in laboratory plasmas in which $T_i \ll T_e$ is common. Along short wavelength, acoustic ion wave converts to a wave with constant frequency. There is complementary behaviour between electeric waves and acoustic ion ones. Acoustic ion waves mainly are waves with constant velocity but they convert to single wave in big K.

When there is magnetic field, it is possible to exist several types of waves. Electrons in flat wave like as plasma fluctuation form density and diluted regions. Waves moving with angle compared with magnetic field have peaks and lowest point which have separated from each other by distance higher than $\frac{\lambda}{2}$, because electrons only can move along magnetic field. If magnetic field is very big, their acceleration becomes less and frequency is less than ω_p.

If scattering direction becomes directional than magnetic field. There is plasma fluctuation and combined one at the same time. If scattering direction and electeric field are along x axle and scattering component in this direction K_x is larger than cross scattering direction, the wave will be longitudinal. If scattering in the direction of K_z is larger than lengthwise scattering direction, the wave will be latitudinal.

Electrons have so small larmor beam that they can move along x to maintain the neuter of charge. Electeric field direct them backwards and forwards in surrounding direction. If magnetic field completely is not vertical to scattering direction, electrons can move along magnetic field and carry the charge from negative region to positive one and do Debye shielding. Ions cannot do this action effectively, because their inertia prevents them from moving long distance in wave. So, you can neglect propagation component in other direction for ions.

Ions are so heavy that they don't move by related frequency and they form constant homogeneous background of positive charge , when refractive index $n = \frac{C}{v_\varphi} = \frac{cK}{\omega}$ is 0 ; that is, when wavelength is infinite , intensification occurs that refractive index become infinite when wave length is 0. When an inside region being wave in which plasma and cyclotron frequencies change scatters, it is possible that bearing cuts off and intensifies.

The wave usually reflects in cut-off process and is absorbed in intensification. Intensification occurs in points of plasma in which ${\omega_n}^2 = {\omega_p}^2 + {\omega_c}^2 = \omega^2$ When a wave with given approaches intensification point, phase velocity and its group approach 0 and the wave energy converts to combined fluctuations. In intensification, cross wave losses its electromagnetic property and become electrostatic fluctuation. Faraday rotation is proposed for plasmas with high density. Faraday rotation only is proposed in low density when the path is very too long that is not placed in the Stern-Gerlach experiment by free electron.

When there is magnetic field, the wave is hydromagnetic. It is related to ion fluctuation with low frequency in the presence of magnetic field. Hydromagnetic wave is along magnetic field in the direction of B_0 or Alfven wave and ultramagnetic wave and Alfven in flat geometry with K . hydromagnetic waves with constant Alfven speed $v_{\mathrm{A}} = \frac{\mathrm{B}}{\sqrt{\mu_0 \rho}}$ move along magnetic field.ρ Is the mass density nM.

For ultramagnetic wave, there is $\frac{\omega^2}{K^2} = C^2 \frac{{v_s}^2 + {v_A}^2}{C^2 + {v_A}^2}$ Ultramagnetic scattered vertical to magnetic field. This is sound wave in which density and expansion not only are produced by motions along electeric field but also are produced by $E \times B$ driving within electeric field. When magnetic field and Alfven velocity tend to be 0, wave of ultramagnetic coverts to sound ion wave. When KT , v_s gradient pressure is 0 and the wave has changed to Alfven one , phase velocity ultramagnetic is larger than v_A.

If wave has monoton amplitude to maintain this driving, force is not needed. But if wave amplitude changes, electrons accumulate in regions of small amplitude and overcoming spatial charge needs force. Although coulomb force affects electrons, at last it transforms to ions when colliding with them. One ion wave accelerates by increasing range and its shape is exposed to change. Also, if you see non linear behaviour of plasma, wave shape will change, because interference of same phase with potential.

Ions accelerating to right side are more than those accelerating to left side and the wave becomes higher than acoustic velocity in non-agitated plasma. If wave amplitude was big, the damp occurs without collision with trapping and the wave does not drop monotonic but its amplitude fluctuates when trapped particles in potentials holes moves backward and forward. This landau damp is nonlinear. In plasma, models of short wavelength tend to combine with long and low energy wavelength.

V. FIELDS AND CONDITIONS GOVERNING THEM

In an argument, it is supposed that electeric and magnetic fields are monotonic in relation to space, but they are variable in relation to time. Assuming that electeric field only is alternating, motion has two components: one of them is in the direction of$x$and the polarization driving motion is

$$v_p = \pm \frac{1}{\omega_c B} \frac{dE}{dt} \tag{11}$$

In plasma, polarization causes ions and electrons move around to maintain quasi-neutral of plasma. Motion of ions and electrons in opposite of each other causes polarization current and polarization charge.

$$J_p = ne\left(v_{ip} - v_{ep}\right) = \frac{ne}{eB^2}(m+M)\frac{dE}{dt} = \frac{\rho}{B^2}\frac{dE}{dt} \tag{12}$$

by changing electeric field, ions firstly move toward electeric field, but they are affected by Lorance force $eV \times B$ and begin to move around when reaching same velocity. They dont move in the main direction of their motion. Electeric field constantly make electron accelerate. If there is no electeric field, Larmor beam only changes due to the existence of magnetic field gradient. Particles don't have acceleration and their energy remains constant during the motion. Because $\Gamma_{i\perp}$ is smaller than$\Gamma_{e\perp}$, cross electeric field causes electron to distribute and ion to distribute slowly.

This process continues so that electron and ion distribute in same rate. But magnetic field has little effect on distributing when ${\omega_c}^2\tau^2 \gg 1$ magnetic field considerably decreases distribution rate in cross of magnetic field. Due to lack of current equilibrium along magnetic field, electeric field can have short adjoined. Electeric field causes density difference because draws ion with itself.

It means that negative charge from $\Gamma_{e\perp} < \Gamma_{i\perp}$ can be wasted by electrons exclude along force lines and electron escape occurs. But if electeric field is big enough, cross-section drops so fast that these escaping electrons never collide. They produce beam of accelerated electron which has separated from main part of distribution. If electeric field fluctuates and this fluctuation become lower than plasma fluctuation, electrons will move in opposite direction of electeric field, while ions dont move in time scale.

Negative ions are not affected by weak magnetic field and don't move due to being heavy. When there is magnetic field, even one type of ions can have two temperatures, because forces inflicted in an ion along magnetic field and verdict to it differ from each other. The presence of magnetic field can be same as collision. Magnetic field does not affect Maxwell distribution. Electrons only can move along magnetic field and this depends on magnetic field velocity. This field does not affect electrons moving parallel to magnetic field.

There are usual fluctuations of plasma along magnetic field. Suppose that magnetic field varies over times, these changes will lead to create electeric field and obtained electeric field causes energy and force to move to particles. If magnetic field fluctuates by cyclotron frequency, induced electeric field rotates with some particles and constantly accelerates in Larmor motion. However, $\omega \ll \omega_c$. Consequently, magnetic transformationμwill not be constant and plasma becomes hot. By changing intensity of, magnetic field, Larmor circuits expand and contract.

This issue causes particles to obtain cross energy and disappear and particles in cross-section will have energy exchange. In little change of magnetic field, magnetic moment remains invariant. But if magnetic field changes in time, this invariant of magnetic moment will be not proved. A constant magnetic field never can transfer energy to particles by itself; as a result, Lorance force cannot change particle energy. If magnetic field is 0, there is cut-off component for electromagnetic waves and they are normal light wave in big KC and they are not damped due to the presence of plasma. inhomogeneous magnetic field of magnets produces two magnetic mirrors between which plasma can be trapped, although trapping electrons directly depends on the size of electrons energy during entering magnetic field. This issue is complex and does not have precise resolution.

If a magnetic field is vertical to the path of electrons motion, two open elastic forces of electrostatic field and Lorance force affect electrons, elastic force affecting electrons increases and the frequency becomes bigger than plasma fluctuation frequency. When plasma density limited to 0, plasma frequency also limited to 0 and there is a simple Larmor rotation, because electrostatic forces and density become 0. Where the density is high, magnetic field must be smaller on the contrary, Decrease of magnetic field inside of plasma results from diamagnetism. To overcome damp, magnetic field must be intensive and1T[tesla]. When magnetic field is big, the Alfven velocity becomes high and wavelength inappropriately becomes big unless density becomes high.

If $B \approx 0.32 \quad [T]$ and $n \approx 10^8 m^{-3}$ cyclotron frequency is same as plasma frequency for electron. To have a directional velocity in plasma, this region makes the necessity that there must be electeric field. However, when electeric field remains constant, there is no polarization drift velocity and there is only v_E drift. Magnetic field must remain over time so that magnetic flux; accordingly, larmor radius remains constant. If electeric field and magnetic field become constant, waves are not excited.

VI. MAXWELL DISTRIBUTION

A Maxwell distribution function is given by

$$f_m = \left(\frac{m}{2\pi KT}\right)^{\frac{3}{2}} exp\left(\frac{-v^2}{v_{th}}\right) \tag{13}$$

Maxwell distribution is isotropic so integration is done in spherical space. Velocity component has different mean in the same direction, v_x is 0 for an isotropic distribution but v_x is not 0.

$$|\overline{v_x}| = \int |\ v_x|\, f_m\left(v\right)\ d^3v = \left(\frac{m}{2\pi KT}\right)^{\frac{3}{2}} \iiint_{-\infty}^{+\infty} dv_y\ dv_z\ \ (2v_x\ )\, dv_x\ exp\left(\frac{-{v_x}^2}{v_{th}}\right) exp\left(\frac{-{v_y}^2}{v_{th}}\right) exp\left(\frac{-{v_z}^2}{v_{th}}\right) \tag{14}$$

You have following equation by simplifying :

$$|\overline{v_x}| = \left(\pi {v_{th}}^2\right)^{-\frac{3}{2}} \pi {v_{th}}^4 = \pi^{-\frac{1}{2}} v_{th} = \sqrt{\frac{2KT}{\pi m}} \tag{15}$$

in Stern-Gerlach experiment by free electrons, Maxwell distribution will changed to non-Maxwell when spin of free electron is exposed to inhomogeneous magnetic field. Observed distribution in this experiment is moving Maxwell distribution. Boltzmann equation simply states that changes of Maxwell distribution function is 0 by time unless there is collision. If collision occurs, particles can scatter and distribution function can change.

Intensive electrons are affected due to interaction between particle and wave and their distribution function is changed by electeric field. There are electrons moving slower than wave in a plasma, but slow electrons are more than fast electrons in Maxwell distribution; so, evaluation whether the electron distribution is Maxwellian or not is important in Stern-Gerlach experiment.Figure1a,1b If distribution function remains constant over time and along the ways of particle, non-damped electeric waves can be produced. When waves cause smooth distribution, waves become stable.

If distribution function of fast particles is more than slow ones, the wave can be aroused; as a result, particles obtaining energy from wave are more than those giving wave energy. However, wave becomes damp. When particles with $v \approx v_\varphi$ are trapped in a wave, Maxwell distribution function spreads in the vicinity of phase rate. Fluid theory does not distinguish among distributions.

In weak ionized environments, correlation equation.

$\frac{\partial n}{\partial t} - D\nabla^2 n = Q_{(r)}$ becomes $\frac{\partial n}{\partial t} = 0$ in constant state.

In constant state, electrons completely follow Boltzmann relation. Electron density decreases exponentially, ion density also drops because ions accelerate by sheath potential. If ions accelerate by sheath potential, $\nabla^2 n = \frac{Q_{(r)}}{D}$ will be. source $Q_{(r)}$ is appropriate to electron density. If source is linear, such source will produce a band of high energy electrons and density distribution will be infinite in centre of linear source and density will be $n = n_0 ln\left(\frac{a}{r}\right)$ Precise identification of density near of axle is not possible by neglecting finite width of source. Also, density is changed in shocked wave. $n = \frac{n_0}{\sqrt{1-\frac{2e\varphi}{M{v_0}^2}}}$

if ions begin to move in high speed , it is expected that density gradually drops because sheath field causes quite little change in their velocity. But if ions have low energy, density drops gradually. The density can be obtained by Maxwell distribution function

$$n_{(r,t)} = \int_{-\infty}^{+\infty} f_{(r,v,t)} \quad dv \tag{16}$$

If distribution is changed by density, the problem is non-linear.

VII. COLLISION AND ITS EFFECT

When particle velocity becomes higher by electeric field, its velocity constantly increases, but when there is the collision or particles are faced with magnetic field, they reach a special velocity on the basis of electeric field. When, there is collision between ion and electron, slope angle of particle changes by collision and they are scattered inside the waste cone and disappeared. Electrons are more easily wasted when they collide, because their collision frequency is higher. Collided particles can transfer some of their direction and kinetic energies to energy in other directions.

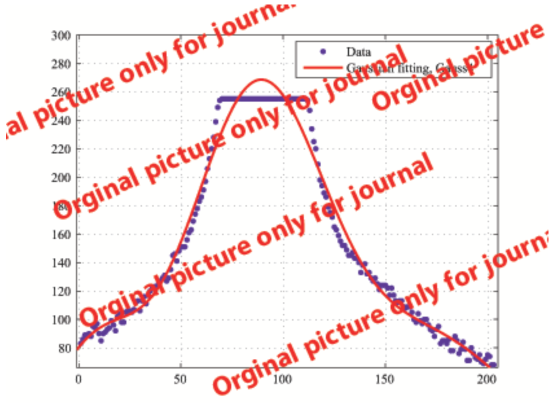
In cold plasma, there is little high energy collision to occur. Collision rate among ions or electrons is higher than collision rate between an electron and an ion. When an ion and an electron collide with each other, especially in partial velocity, it is possible that their recombination produces neutral atom. If there is collision, particles move toward lamp wells in the cross of magnetic field and in the direction of gradiant. Larmor beam may change.

In a collision, guide centre position is changed and particle moves random to the direction in cathore. Single particles are transferred in cathore due to repeated collisions. If there is no collision, the particles are not scattered in vertical direction and a particle continues to rotate around the same force line. Due to electeric fields or gradients in magnetic fields, particle moves across magnetic field. If collision frequency is very high, the rate of velocity component changes vertical to magnetic field can be neglected. All collisions among charged particles are coulomb collisions. Cross-section of coulomb collision depends on velocity. If collision of two same particles is facing particles ways only exchange but velocity is reversed.

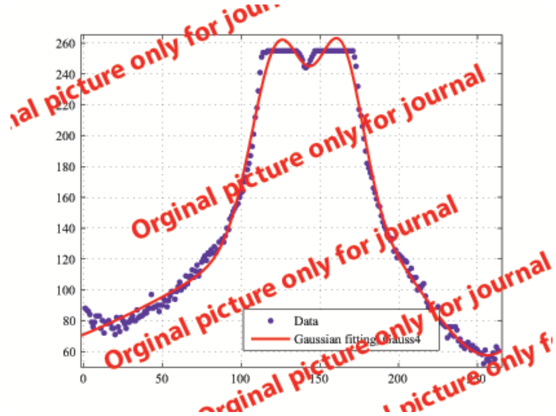
Usually, collisions among same particles make very low distribution unless in special cases such as ions with neutral atoms of particle collision cause internal tensions of each fluid. Ion-ion collision occurs in exchange for each collision of ion exchange. When two particles with opposed charges collide each other, the condition is different. In the worse condition of collision, particle velocity will be reversed after colliding and scatter. Collisions of different particles cause distribution.

In successive collisions with electrons, ion reaction moves around by long-range coulomb field; so, the resistance reason of momentum will be same for ions and electrons in each collision of distribution. When an electron collides with neutral atoms, it does not approach an atom in atomic dimensions scale and no motion is exerted to it. Plasma without collision acts as a fluid of collision. Fluid image for particle motions is not suitable in direction of magnetic field because they have free current in this direction.

Collision leads to create acoustic wave. Due to their charge, ions can transfer vibration to each other; as a result, electrons are reflected. coulombian potential becomes equilibrium in plasma environment so that same number of electrons and ions reach wells in every second. By adjoining lamp body to ground, body potential and wells can be neglected easily.



(a)
MATLAB Gaussian fitting,
Gaussian4, Before Magnetic Field.



(b)
MATLAB Gaussian fitting,
Gaussian4, After Magnetic Field.

FIG. 1: Figures a and b Shows the current profile of Stern-Gerlach experiment by free electron , the profile well shows that electron distribution is a Gaussian distribution. When magnets adjoin the ground, electron band is seen as a point and when they are affected by inhomogeneous magnet field, separation occurs, but when magnets is not connect to the ground, it seems to be linear. When they are affected by inhomogeneous magnet field, the separation is seen as loop rotating by increasing magnet field in the plate. Separation is the obtained result being similar to Stern-Gerlach experiment by silver atom but it is different.

When ions and electrons collide with wells are combined again and removed, potential barrier sets its height in such a way that flux of electrons with enough to pass the potential barrier become same as flux of ions reaching wells. The Bohm sheath criterion shows that ions must enter the sheath with velocity higher than acoustic velocity.

When electron reaches a level occupied by atoms, it will lose its momentum, $\lambda_m = \frac{1}{n\sigma}$, $\tau = \frac{\lambda_m}{v}$, collision frequency in terms of special resistance

$$f = n\sigma v = \frac{ne^4}{16\pi{\varepsilon_0}^2 mv^3} \tag{17}$$

and the cross section of coulomb collision

$$\triangle P \approx \frac{e^2}{4\pi\varepsilon_0 r_0 v} \tag{18}$$

$$\sigma = \pi{r_0}^2 = \frac{e^4}{16\pi{\varepsilon_0}^2 m^2 v^4} \tag{19}$$

and η is independent from density. The resistance is due to collision

$$\eta = \frac{e^2}{16\pi{\varepsilon_0}^2 mv^3} \tag{20}$$

In a ionized environment , there is no cross motion , if cross field is exerted in homogeneous , both types will be drove by $E \times B$ rate, because there is no partial drive between two types and they don't collide each other and there is no motion in the direction of electeric field. quick electrons collide with high velocity in the end of distribution. In absence of collision, distribution function changes can be ignored.

VIII. THERMAL MOTION AND ITS EFFECTS

Thermal motion in plasma causes plasma fluctuation. Thermal velocity is mentioned by relation . $v_{th} = \sqrt{\frac{2K_0T}{m}}$ Electrons currenting to adjacent layers by their thermal velocity carry information about what occurs in fluctuating region.

In short waves, information are transferred by thermal velocity and it is transferred slower than thermal velocity in long waves and thermal motions of momentum transfer very low resultant to adjacent layers. T_i Is ion temperature and T_e is electron temperature. Electron temperature is used to define the wavelength of Debye, because electrons being more movable than ions produce additional negative charge by their motion and do the shielding. Electrons are so movable that their thermal conductivity is infinite. So, you can suppose electrons single temperature.

If plasma is cold,$T_i = T_e = 0$, there is no thermal movement and Debye shielding will be complete. If plasma has a temperature, particle being in the edge of plasma cloud can simply scattered by their thermal energy. When plasma is hot , the level of coulomb profile decreases and special resistance drops by increasing temperature. In high temperature, plasma is so suitable conduct for heat that ohm heating will be very slow process in that point. In plasmas with high temperature, collision rarely occurs. Deviation from thermal equilibrium can remain in long time.

If thermal speed v_{th} is high, waves will strongly be damp. In hot plasma, collisions can be neglected, if the force becomes electromagnetic. When velocity distribution is Maxwell and density and magnetic field are homogeneous, you have the highest entropy, there is no free energy to arouse the waves. But free energy can cause waves to be aroused, and then the equilibrium will be transient. Transient is the motion which decreases the free energy and approximates plasma to real thermodynamic equilibrium. When there is no thermal velocity, group velocity will be $v_{group} = 0$ If temperature in system becomes clear, the standard of plasma sheath can be used for estimating ions flux. However, gathered ion current are

$$I = n_s e A \sqrt{\frac{KT_e}{M}} \tag{21}$$

the edge of plasma sheath has potential $\varphi_s \approx -\frac{1}{2}\frac{KT_e}{e}$ Compared with plasma body, while ion wave scatters in cold plasma it will have phase velocity.

IX. DISPERSION AND DAMPING

For acoustic ionic waves, Dispersion relation is

$$\frac{\omega}{\mathrm{K}} = \sqrt{\frac{KT_e + \gamma KT_i}{M}} \equiv v_s \tag{22}$$

That v_s is sound velocity in plasma. Assuming that plasma approximation, dispersion relation will be $\omega^2 = {\Omega_c}^2 + K{v_s}^2$ for electrostatic ionic cyclotron waves and if electrons provide debye shielding, acoustic dispersion relation $\omega^2 = K^2{v_s}^2$ is valid. Dispersion relation is $\omega^2 = {\omega_p}^2 + {\omega_c}^2{\omega_h}^2$ when there is vertical magnetic field. ω_p is the frequency of plasma fluctuation, ω_c is intensification frequency and ω_h his combined frequency.

For electromagnetic, this relation is $\omega^2{=}{\omega_p}^2 + C^2K^2$, when plasma scatters without magnetic field. This relation is $\frac{C^2K^2}{\omega^2} = \frac{C^2}{{v_\varphi}^2} = 1 - \frac{{\omega_p}^2}{\omega^2}\frac{\omega^2-{\omega_p}^2}{\omega^2-{\omega_n}^2}$ when there is cross wave and electromagnetic waves are vertical to magnetic field.

Equation

$$v = \frac{1}{mnf}\left(\pm enE - KT\ \nabla n\right) = \pm\frac{e}{mf}E - \frac{KT}{mf}\frac{\nabla n}{n} \tag{23}$$

Is for plasma with single frequency. Motion coefficient is equation $\mu\frac{|q|}{mf}$ and scattering coefficient is equation $D \equiv \frac{KT}{mf}$ and Einstein relation is $\mu = \frac{qD}{KT}$ and particle flux relation is $\Gamma_j = nv_j = \pm\mu nE - D\ \nabla n$

Fick's laws of diffusion is $\Gamma = -D\nabla n$, Fick's laws diffusion occurs when $E = 0$ or when particles are not charged as a result $\mu = 0$.

When ions and electrons reach wells recombine again. If Γ_i^* ,Γ_e are not equal, great inequality exist. If plasma is very larger than Debye wavelength, it must be quasi-neutral and it is expected that the scattering rates of ions and electrons set themselves so that two types exclude from one rate. Electrons being lighter have high thermal velocity and try to leave the plasma before ions. Positive charge remains and electeric field resulting from this polarity is in such way that delay the waste of electrons and it accelerates the ions wastes.

The necessary electeric field is found by $\Gamma_e = \Gamma_i$

$$E = \frac{D_i - D_e}{\mu_i + \mu_e}\frac{\nabla n}{n} \tag{24}$$

and common flux

$$\Gamma = \frac{-\mu_i D_e + \mu_e D_i}{\mu_i + \mu_e}\ \nabla n \tag{25}$$

If $\mu_i \ll \mu_e$, scattering index can be stated in form of two polar scattering index

$$D_a = \frac{\mu_i D_e + \mu_e D_i}{\mu_i + \mu_e} \tag{26}$$

While in $T_i = T_e$, scattering rate for two types of electron and ion is controlled by slower type. However, it is expected for scattering coefficient that $D_A = 2D_i$.

In parallel scattering and in the cross of magnetic field , electrons moves faster than ions due to their higher thermal speed and they move slower in vertical scattering of electrons. Because they have smaller Larmor radiuse. Ions mainly scatter in beam direction while electrons scatter along magnetic field. Whether this issue occurs or not depends on experimental condition. Each type scatters with different rate radically.

If magnetic field is more than given magnitude, scattering magnitude will increase in plasma. Plasma waste can be presented with a negative span term in correlation equation. It is clear that this term is $n_e n_i = n^2$.If scattering term is ignored in correlation equation, you will have $\frac{\partial n}{\partial t} = -\alpha n^2$,$\alpha$ is reflective index. There is no direct method to set primary and bounded condition through responds when the scattering is nonlinear.

By passing current through plasma, plasma begin to heat. Electeric resistance of plasma against passing current causes waste and the increase of electron heat. In motion vertical to magnetic field , slow electrons with small Larmor beam resist more than those with parallel motions. Degree of resistance η in vertical direction to magnetic field is twofold than resistance in paralleled direction.

If plasma lacks resistance , it must form an infinite current that this is impossible ; however, when moving around , plasma can bend magnetic field lines. Magnetic field lines moves in plasma and induced current causes plasma to be heated. This energy is driven from magnetic field energy. According to Magneto-hydrodynamics , Distribution coefficient (factor) for completely ionized gas is $D_{\perp} = \frac{\eta\, n \sum KT}{B^2}$, distribution coefficient is not constant in completely ionized gas. The density of distribution focuses is not identified by neutral atoms.

But it is the same density of plasma. Because η is corresponding to $(KT)^{\frac{3}{2}}$, $D_{\perp}$ decreases by increasing temperature in completely ionized gas.

When high energy beam of particles passes through plasma or current which is absorbed inside plasma, drift energy is used to excite waves and fluctuation energy is obtained in ordered state. When external non -magnetic force affects plasma , this force excites instability (like as gravity force). When there is a curved magnetic field , escape force affecting plasma and resulting from particle motion along curved lines of force acts as gravity force. Plasma pressure tends to expand and expansive energy can lead to excite instability. This kind of energy usually exists in each finite plasma.

If distributions are not Maxwell in real , there will be no thermodynamic equilibrium and instabilities can be caused through each difference of velocity difference. In mirror tools, there is the waste of particle shortage with ratio $\frac{v_{\|}}{v}{}_{\perp}$ due to cone, and this difference leads to waste cone instability. An instability with high frequency in the vicinity of ω_P cannot affects motions of heavy ions. Low frequency instability can form unusual wastes through $E \times B$ drifts. Trapping electron in electrostatic potential (wave) is nonlinear which can not be investigated by directly solving Velasof equation. Landau damping is the wave without energy wasting and an reversible process.

Landau damping does not include collision or waste, it is one of the properties of plasmas without collision. This effect is related to particles in distributing intensive particles having same velocity as phase velocity. These particles move along wave and don't feel electeric field with high fluctuation. However, they can effectively exchange energy with wave. Damping needs continuous increase in kinetic energy driven from wave energy. Damping is constant for non-trapped particles over times. Trapped and non-trapped particles don't cause linear Landau damping.

When wave amplitude is small, few electrons are necessary to be steady the damping rate. But damping rate can be constant. Electrons obtain energy; so, waves lose energy. This is the linear Landau damping and depends on given primary condition. After long time of phase difference, electrons so collide with each other that primary distribution must be ignored and there is no average energy portion. In Landau damping, different models have phase difference toward each other.

A single wave can decay by producing first frequency harmonic of their base and they produce new waves by beat frequency after interacting harmonics with primary waves, beat waves can be so big that they produce constant spectrum. Beat of different waves can combined with each other and produce permanent spectrum. When there is permanent spectrum of frequency , plasma will be in turbulent. Like fluid hydrodynamic, This state must be described statistically. Turbulence in plasma causes plasma resistance and prevents the increase in particle velocity.

In plasma turbulence, electrons become slow due to colliding with Brownian motion of electeric field. When usual resistance is inefficient to heat plasma to high temperature, this effect is used. In fluid dynamics , long wavelength model disintegrate to short wavelength, because big turbulent currents have more energy and can disintegrate by dividing into small turbulent currents having low energy. Small turbulent currents convert their adhesion of kinetic energy to heat by damping. There is no energy waste in big k in which Landau damping can occur. Damping in fluctuation results from collisions.

X. MOTION EQUATIONS IN PLASMA

Generally, the path of charged particle is spiral in the air. Electrons are excitable due to their lightness and if a force is exerted them become accelerated. Because electrons can not leave the region without leaving a big ionic charge , forces of pressure gradient and electrostatic on the electrons must be in complete equilibrium which leads to Boltzmann relation $\frac{n_e}{n_i} = \frac{e\varphi}{KT_e}$.

When propagation direction is vertical to magnetic field direction , electrons cannot maintain the neuter of charge by currenting along force lines; however, electrons move by following Boltzmann relation

$$mn\left[\frac{\partial u}{\partial t} + (u.\nabla)\, u\right] = qn\left[E + u \times B\right] - \nabla.P \qquad (27)$$

If particles are affected by electeric and magnetic fields , this motion will be the total motions of the circle Larmor rotation and Velocity of direction center

$$v_E = \frac{\mathrm{E} \times \mathrm{B}}{\mathrm{B}^2} \equiv v_E = \frac{E}{B} \tag{28}$$

The velocity of direction center v_E is independent of $v_\perp, m, q$ Velocity resulting from gravity force is

$$v_g = \frac{1}{q}\frac{mg \times B}{B^2} \tag{29}$$

Suppose that lines of magnetic field don't have curve , so drift velocity is written as follows

$$v_{\nabla B} = \pm\frac{1}{2} v_{\perp} r_l \frac{B \times \nabla B}{B^2} \tag{30}$$

Now, if magnetic field lines have curve, this field does not follow Maxwell relation. Assuming that R_c is the curve beam of magnetic field lines and this field is constant and particles are affected by centrifugal force in its thermal moving along field lines causing velocity of direction center which is given

$$F_{cf} = \frac{m{v_\parallel}^2}{R_c}\hat{r} = m{v_\parallel}^2 \frac{R_c}{{R_c}^2} \tag{31}$$

, in whichR_c is curve beam and $v_\parallel$ is velocity in the direction of magnetic field. However, velocity will be

$$v_R = \frac{1}{q}\frac{F_{ef} \times B}{B^2} = \frac{m{v_\parallel}^2}{qB^2}\frac{R_c \times B}{{R_c}^2} \tag{32}$$

; as a result, in such field, drift velocity is the sum of curve drift velocity and gradient velocity.

$$v_{R+\nabla B} = \pm\frac{{v_{th}}^2}{R_c \omega_c}\hat{y} = \pm\frac{r_l v_{th}}{R_c}\hat{y} \tag{33}$$

If two particles have same energy, they have same Larmor beam when being within fluid part. However, it is not easy to correspond the particle and fluid images. In fluid calculation, motions of single particle are not considered. When two terms $(v.r)v$ and ∇P are ignored In fluid equation, fluid and single particle equations become same and all particles move together . now, if collisions are added to fluid equation in addition to Brownian thermal motion , you will have

$$mn\left[\frac{\partial v}{\partial t} + (v.\nabla)\, v\right] = qn\left[E + v \times B\right] - \nabla.P - mn\left(\frac{v - v_0}{\tau}\right) \tag{34}$$

$$\nabla.p \approx -\nabla p = -\nabla(nKT) \tag{35}$$

τ is the average free time among collisions. In low velocity , Convective term$(v.\nabla)v$ can be ignored but this term is never ignored in high velocity. Centrifugal force is exerted all present particles in fluid component when moving in curve magnetic field and is as follows $(v.\nabla)v$. For fluids, there is no Gradient velocity resulting from magnetic field.

In absence of magnetic field Ionic fluid equation is

$$Mn\left[\frac{\partial v}{\partial t} + (v.\nabla)\, v\right] = -en\nabla\varphi - \gamma KT\ \nabla n \tag{36}$$

According to electrostatic fluctuation of electron vertical to magnetic field , for long waves in $K \parallel E$ plasma velocity is

$$v_x = \frac{\left(\frac{eE}{im\omega}\right)}{1 - \left(\frac{{\omega_c}^2}{\omega^2}\right)} \tag{37}$$

For long waves in $K \parallel E$ plasma. In cyclotron intensification , $\omega = \omega_c$ becomes infinite v_x component. If electromagnetic waves are vertical to magnetic field (cross waves) ;that is $K \perp E$, there are two possibilities: electeric field can be vertical or parallel to magnetic field. If electeric field is vertical to magnetic one and are affected magnetic field by moving electrons and scattering relation will change , waves with $E \perp B$ tend to be elliptical polarization (than linear polarization) . in such condition, part of wave becomes longititudinal and other part becomes latitudinal. So, when there is latitudinal wave , motion equation is as follows

$$v_y = \frac{-ie}{m\omega}\left[E_y - v_x B_0\right] \tag{38}$$

and

$$v_x = \frac{-ie}{m\omega}\left[E_x + v_y B_0\right] \tag{39}$$

When propagation angle and magnetic field are vertical, ionic motion equation is

$$v_{ix} = \frac{eK}{M\omega}\varphi\left(1 - \frac{{\omega_c}^2}{\Omega^2}\right)^{-1} \tag{40}$$

Group velocity cannot reach light velocity. So , when v_φ is bigger than$C$, group velocity is lower than c.

$$v_\perp = v_E + v_D = \frac{E \times B}{B^2} - \frac{\nabla P \times B}{qnB^2} \tag{41}$$

v_E velocity is same as velocity of direction center but there is a new velocity v_D called diamagnetic velocity. Because v_D is vertical to gradient direction, $(v.\nabla)v$ which was done before can be ignored provided that $E = 0$. If $E = -\nabla\varphi \neq 0$ provided that $\nabla\varphi$, ∇P are in same direction. Diamagnetic velocity sign v_D is changed by P . because the rotatory direction is reversed. v_D size does not depend to mass. Because electrons and ions velocity in opposite directions , a diamagnetic current exists wherever pressure gradient exists

$$j_D = ne\left(v_{Di} - v_{D0}\right) = \left(KT_i + KT_e\right)\frac{B \times \nabla n}{B^2} \quad (42)$$

According to scattering factor $D_{\perp} = \frac{D}{1+{\omega_c}^2\tau^2}$ and vertical motion $\mu_{\perp} = \frac{\mu}{1+\omega_c^2\tau^2}$, drift velocity can be obtained vertical to magnetic field

$$v_{\perp} = \pm\mu_{\perp}E - D_{\perp}\frac{\nabla n}{n} + \frac{v_E + v_D}{1 + \left(\frac{f^2}{{\omega_c}^2}\right)} \quad (43)$$

Vertical field of every type consistes of two parts. v_E and v_D velocity become slow due to colliding with neutral atoms. There are motion and scattering velocity which are parallel to potential gradients and density.

These velocity have same figure related to the time in which the size of magnetic field is 0, but D and μ coefficients are decreased by $1 + (\omega_c)^2\tau^2$. From the view of magneto-hydrodynamic, plasma is described by mass density

$$\rho = n_i M + n_e m \approx n\left(M + m\right) \quad (44)$$

, current density

$$j = e\left(n_i v_i - n_e v_e\right) \approx ne\left(v_i - v_e\right) \quad (45)$$

and mass velocity

$$v = \frac{1}{\rho}\left(n_i M v_i + n_e m v_e\right) \approx \frac{M v_i + m v_e}{M + m} \quad (46)$$

, like as a fluid. So , the equations of fluid motion can be written as follows

$$Mn\frac{\partial v}{\partial t} = qn\left(E + V \times B\right) - \ \nabla P - \nabla.\pi + \ P_{ie} \quad (47)$$

Because homonym collisions cause tensions inside the fluid. π is added to the equation, but term $\nabla.\pi$ is ignored because scattering is not high. And momentum results from ion-electron collision $P_{ie} = \eta e^2 n^2\left(v_i - v_e\right)$ Motion equation of single fluid

$$\rho\frac{\partial v}{\partial t} = j \times B - \nabla P + \rho g \quad (48)$$

describes mass current; however, scattering velocity in ionized plasma is

$$v_{\perp} = \frac{E \times B}{B^2} - \frac{\eta_{\perp}}{B^2}\nabla P \quad (49)$$

Density of electeric charge can form electeric fields causing $E \times B$ velocity toward walls. Currents inside plasma can produce magnetic field which causes gradient velocity of magnetic field outside. From the view of single particle of diamagnetic current , Latitudinal diamagnetic current

$$j_{\perp} = \frac{B \times \nabla P}{B^2} = \left(KT_i + KT_e\right)\frac{B \times \nabla n}{B^2} \quad (50)$$

Results from Larmor rotation of particles, because density gradient is not 0. From view of a fluid , diamagnetic current is produced by ∇P force in magnetic field. Force of diamagnetic current $j \times B$ neutralizes force of pressure gradient in stable state. If the velocity of particles is more than sound velocity , the acoustic shock wave is produced

$$v = \sqrt{{v_0}^2 - \frac{2e\varphi}{M}} \quad (51)$$

Electron wave can not convert to two other electron wave, because there is no way to place differential vector on electeric curve. Moving an electron wave causes an ionic wave to move opposite of its moving direction. Total velocity equals to sum of fluid velocity and thermal one.

XI. LANGMUIR PROBE AND CALCULATE THE SPEED OF FREE ELECTRONS IN ACTION

Langmuir probe is used to obtain an experimental criterion of electrons velocity in lamp. Langmuir probe includes one or more electrodes which are directed toward plasma environment. Electron density , electron temperature and plasma potential can be precisely obtained by exerting potential and measuring current and voltage , Ref[11, 12]. Measuring current and voltage of system plasma and its results named distinguishing curve or probe current distinguishing Ref[13--15] make physical quantity of plasma possible.

Usually, experiment of Langmuir probe is done for 1 Torr pressure or lower, and used voltage is DC one including interval about 300 *volt* to several kilovolt. According to laboratory results, electrons and ions usually do not have same energy and electron temperature is more, but electron density is same as ion density , Ref[13--15].

When a narrow probe enters plasma environment , it quickly stores negative potential and gathers electrons until reaching saturation state and removes electrons. When electric charge are stored enough , electrons often can affect positive ions in their vicinity. Floating probe will have potential named floating potential φ_f until positive ions current equal to electrons current. Ref[11, 16--18]

If environment is located in the potential difference , potential difference may lead to ionize particles. In experiment of Langmuir probe with electric letting-off, bright surfaces are simply visible in low vacuum and this shows that non-straight motions of electrons and collision with neutral atoms are in low vacuum.The Stern-Gerlach experiment by free electron need a high vacuum,It makes by Getter and another systems on the experiment. Figure4.

Forming plasma always accompanies with producing light and heat. Whatever electron temperature of plasma increases, electron and atom motions increases. Plasma potential increases by moving away from cathode until its changes become little in the beginning of negative bright region. Potential linearly increases from this region to close of anode having the highest potential. Figure2 Ref[19].

Langmuir probe is adjoined to a source of variable and adjustable voltage Figure3. The voltage obtained by measuring distinguishing curve of plasma and its parameters adjoins its forward and reversed bias and is measured in lieu of different voltages of probe current.Figure3.

Distinguishing curve has consisted of three areas. First area is floating potential φ_f of plasma. This potential exists when probe current equals to 0. In potentials less than φ_f , gentle slope of changes of ionic saturation current is seen. In transition area, potentials more than φ_f , curve rises by steep slope exponentially. Transition area will have gentle slope in the upper terminal in which curve value shows electeric saturation current. If potential of probe bias is φ_b and plasma potential is φ_p , electron and ion current in plasma can be obtained in temperature T_i and T_e according to Maxwell distribution. Relation of ion and electron is as follows

$$I_i\left(\varphi_b\right) = \begin{cases} -I_{is} \quad e^{\left(\frac{e(\varphi_p-\varphi_b)}{KT_i}\right)} & \varphi_b \geq \varphi_p \\ -I_{is} & \varphi_b < \varphi_p \end{cases} \tag{52}$$

$$I_e\left(\varphi_b\right) = \begin{cases} I_{es} \quad e^{-\left(\frac{e(\varphi_p-\varphi_b)}{KT_e}\right)} & \varphi_b \leq \varphi_p \\ I_{es} & \varphi_b > \varphi_p \end{cases} \tag{53}$$

If electron and ion temperatures are comparable, the saturation current of electron and ion are obtained as follows Ref[20].

$$I_{is} = \frac{1}{4} e n_i v_{i,th} A_{Probe} \tag{54}$$

$$I_{es} = \frac{1}{4} e n_e v_{e,th} A_{Probe} \tag{55}$$

According to the discussion of thermal velocity of electron and ion

$$v_{i,th} = \sqrt{\frac{8K_B T_i}{\pi\ m_i}} = \sqrt{\frac{8K_B}{\pi\ m_i}}\sqrt{T_i} = 22.89\ \sqrt{T_i} \tag{56}$$

$$v_{i,th} = \sqrt{\frac{8eT_{iV}}{\pi\ m_i}} = 0.24 \times 10^4\ \sqrt{T_{iV}} \tag{57}$$

$$v_{e,th} = \sqrt{\frac{8K_B T_e}{\pi\ m_e}} = \sqrt{\frac{8\ K_B}{\pi\ m_e}}\sqrt{T_e} = 0.18\ \times 10^4\sqrt{T_e} \tag{58}$$

$$v_{e,th} = \sqrt{\frac{8eT_{eV}}{\pi\ m_e}} = 6.7\ \times 10^5\sqrt{T_{eV}} \tag{59}$$

When electron temperature is higher than ion one, ionic saturation current does not calculated by relation of ionic thermal velocity and it can be obtained by Bohme relation $T_e \gg T_i$. Ref[11, 21--25].

According to Debye length relation

$$\lambda_d = \sqrt{\frac{\varepsilon_0 K T_e}{e^2 n_e}} = 7.4 \times 10^3\sqrt{\frac{T_{eV}}{n_e}} \tag{60}$$

and plasma approximation and electeric neuter of plasma , $I_e + I_i = 0$, it can be written Ref[14]

$$\ln I_{probe} - \ln I_{sat} = \frac{e\left(\varphi_{bias} - \varphi_f\right)}{KT_e} \tag{61}$$

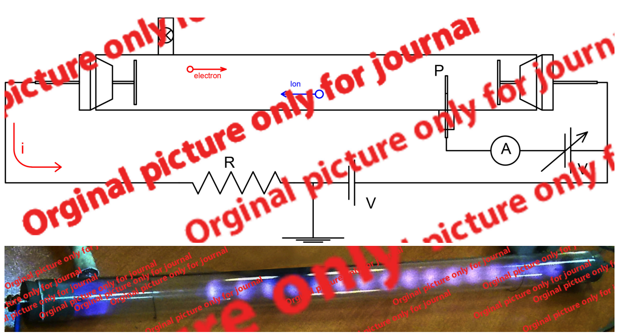


FIG. 2: The figure shows Langmuir Probes experiment, this experiment is used to obtain the properties of plasma including the speed of free electron.

FIG. 3: The figure shows I-V properties of Langmuir probes experiment

Floating potential can be simplified and rewritten as follows,Ref[13--15].

$$\varphi_f = \varphi_p + \left(\frac{KT_e}{e}\right) \ln\left(0.6\sqrt{2\pi\frac{m_e}{m_i}}\right) \quad (62)$$

After obtaining distinguishing curve , electron temperature can easily be calculated by curve slope of relation

$$\frac{d\ln I_p}{dV} = \frac{1}{T_{eV}} \quad (63)$$

So, estimation of thermal velocity of electrons is obtained. Experimental evidences of a Langmuir experiment in 1800 *volt* and 1300 *volt* can help to understand the decreased velocity estimation of electrons ,TableIII. By distinguishing curve , other parameters of plasma can be obtained , Figure2.

It is necessary to note that hight vaccum in common experiment of Langmuir probe is less than used vacuum in experimented lamp. According to results from Langmuir probe experiments and classical table of electron velocity, TableIII.

It is clear that in voltage about 1800 *volt* and milliamper current of cathode, electrons velocity effectively decrease by mentioned factors such as collision and coulomb force ,etc. And it drops about 10% to 20% than its classical prediction TableIII and it decreases from $\approx (10)^4[\frac{m}{s}]$ to $\approx (10)^5[\frac{m}{s}]$ and $\approx (10)^7[\frac{m}{s}]$ obtained from Langmuir probe experiment.

According to momentum drop and relation Equation8, it is clear that if electron velocity decreases due to mentioned factors, gradient of magnetic field being necessary to separate electrons is about Tesla percentage meter which is lower than what is supposed. According to the issue of a paper recently published , Ref[1], it is expected that the density of magnetic field lines considerably increases in the sharp top hedge of magnetic , according to sharp top hedge (a). in the relation obtained

$$\nabla B = \frac{\partial B}{\partial z} = \frac{1}{a}\, B \quad (64)$$

If the beam of sharp pointed magnet is limited in micrometer or nano- meter degree , it is identified that gradient of produced magnetic field increases , even if magnetic field is weak , by multiplying $\frac{1}{a}$ by it; as a result two factors of decreasing electron velocity and increasing density of magnetic field lines in sharp pointed magnet of edge can effectively lead to observe mentioned phenomenon.

TABLE I: This table shows $\mathbf{T}_{ev}$ and $\mathbf{T}_e$ that calculated by lungmuir porbe in diffrent voltage.In the lamp of Stern-Gerlach experiment by free electrons, fixed current is $I_p \approx I_{cathode} \approx 0.003$ then it can calculate the electron velocity by equation equations 56 57 58 59

Voltage (*volt*)	$\mathbf{T}_{ev}$ *in lungmuir theory* (*eV*)	$\mathbf{T}_e$ *in lungmuir theory* (*K*)
10	1.72142	19796.4
100	17.2142	197964
200	34.4285	395928
300	51.6427	593891
400	68.857	791855
500	86.0712	989819
600	103.285	1187783
700	120.5	1385747
800	137.714	1583710
900	154.928	178167450
1000	172.142	1979638
2000	344.285	3959276
3000	516.427	5938914
4000	688.57	7918552
5000	860.712	9898190
6000	1032.85	1.2E+07
7000	1205	1.4E+07
8000	1377.14	1.6E+07
9000	1549.28	1.8E+07
10000	1721.42	2E+07
20000	3442.85	4E+07
30000	5164.27	5.9E+07
40000	6885.7	7.9E+07
50000	8607.12	9.9E+07
60000	10328.5	1.2E+08
70000	12050	1.4E+08
80000	13771.4	1.6E+08
90000	15492.8	1.8E+08
100000	17214.2	2E+08
200000	34428.5	4E+08
300000	51642.7	5.9E+08
400000	68857	7.9E+08
500000	86071.2	9.9E+08
600000	103285	1.2E+09
700000	120500	1.4E+09
800000	137714	1.6E+09
900000	154928	1.8E+09
1000000	172142	2E+09

XII. EXPERIMENT AND USED COMPONENTS IN THE EXPERIMENT

The idea of making lamp is initially proposed by Vladimir Zworykin scholar. After that, this idea gradually has been completed since 1950 like as Iconoscopes , Image Dissector , Image Orthicon , and Videocon. Of course, what you know in today's lamp includes two model

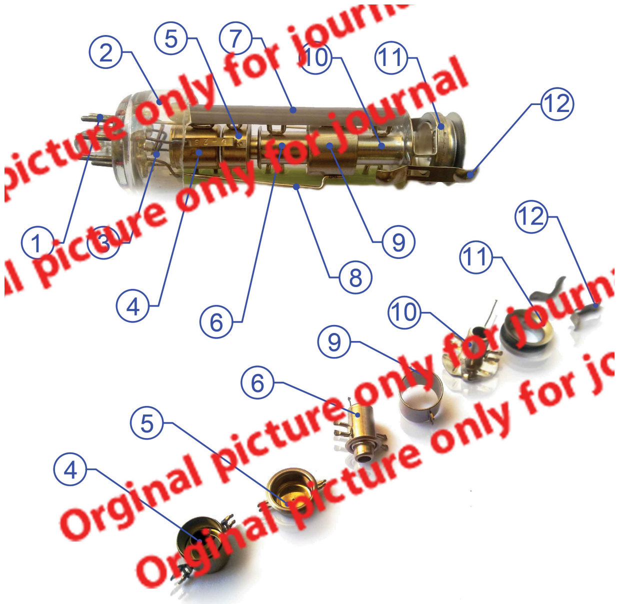


FIG. 4:
This figure shows the components (parts) of electron gun. 1) Legs, 2) lamp glass, 3) the leg of tungsten fittings, 4) the preserving container of tungsten and cathode tube-this piece sets the throw (scattering) angle in addition to making parallel. 5) It plays main role in separating negative ions. 6,10) grid plates are 2 and 3 if they have same voltage they make the parallel beams. 7) it is the plastic leg holding the pieces. 8) metal leg holding and adjoining the plates 9) this plate makes a curvature in the main way of electrons and removes remained negative electrons. 11) Gitter hoop to remove neutral atoms and ions remaining after diffusion and making high vacuum 12) holding antennas.

of Image Orthicon and Videocon. A lamp has three parts: plate of photocathode, collector hoop and electron gun. Collector hoop collects electrons which are lost by silver and Cesium during forming on photocathode plate. Electron gun Figure4 separates free electrons from hot filament and throws them toward fluorescence plate. Filament voltage usually in 2.5 *volt* to 12.6 *volt* in interval. There are different guns and all of them have common aspects.

An electron gun consists of five main parts: filament (H),cathode (k), grid plate (1), grid plate (2), grid plate (3). If voltage of grid plates 2, 3 are different, these plates act as particle. Image lamps usually have grid plates 2, 3 with different voltage. This causes free electron beam changes like as light beam exposed to electric lens. Here, voltage difference of these plates can change density of free electron beam and if plate voltage of grids 2, 3 have noise or voltage fluctuation, it makes disturbance in common path of heavier electrons and ions. This will produces a secondary fluctuating spot on plate in experiment. To avoid this event, a control circuit is used. This event is not ideal in experiment of Stern-Gerlach experiment phenomenon by free electron beam.
Simultaneous fluctuation of grid plates voltage in image lamps causes the change in light intensification named Blooming ; so, to avoid such event and make parallel and avoid scattering free electron beam, plate voltage of grids 2,3 are same and connected. When filament connects to suitable voltage , cathode becomes hot and other negative particles are thrown additional to throwing electron from cathode that their weight is higher than electron one and set of these heavy electron with electron beam are not affected by weak magnetic field of deviating coils and don't deviate due to having high weight .

Since negative ions have straight path toward image plate, they can remove phosphorus mucilage of image lamp and brown spot remains and burn plate Phosphorescence. To prevent from the effect of negative ions on plate of image lamp , plate of grid 1 and cathode are relatively made oblique toward the main axel of lamp so that negative ions and electrons locate in same throwing angle and primary deviation, although Gitter hoops absorbs high percent of atoms and some of ions after primary vacuum-making and excludes them from system , this primary deviation causes negative ions and electrons to deviate opposite of main direction then voltage of plate of grids 2,3 causes free electron being lighter directs toward main path and become parallel to parallel path; so , separated heavy negative ions deviate opposite the main direction and free electrons direct toward plate.

This mechanism separating heavy ions from electrons is a standard in making electron guns. In some lamps of special image systems , especially color image lamps, a magnetic is used to separate electrons from negative ions that motion force is low and excludes it from lamp to separate negative ions from electron.TableII

This piece is in form of horseshoe and is placed out of lamp around the cathode and is named ion trap, it usually used in color image systems or systems with big size and in which separating negative ions from electrons in high voltage is difficult. Ion trap piece which is usually used in some special image lamps have magnetic intensification between 30-50 Guessian. The presence of this piece only guarantees separation heavy ions from negative electron beam. Using ion trap piece in the Stern-Gerlach with free electron beam does not useful. Because electron gun has been used by setting voltage of grid plate so that this voltage usually has voltage fluctuation. Also all voltages of electeric currents have low grid plate and cathode current is low.

So it is necessary that circuits of these system change so that voltage reaching all plates becomes DC and regulated one. Also, electeric currents must be constant. In an image system, a coil usually deviates free electron beam and directs it towards suitable direction to make

TABLE II: About Phosphorescence plate in television

Phosphorescence duration (second)	Produced light color	Stimulus factor	Phosphorescence material
Average 0.3 to 0.5	Green	Manganese	Zinc silicate
Long time	Green-Blue	Copper	Two Zinc sulphide
Average 0.5	Green-Yellow	Manganese	Zinc beryllium silicate
Average 0.2 to 0.3	White	Silver	Zinc Beryllium Silicate and two Zinc Sulphide
5 microsecond	Blue		Two Calcium Tungsten
	White	Silver	Zinc Sulphide
		Silver	Zinc Calcium Sulphide and Zinc Sulphide
Average 0.0006	Blue and Yellow	Silver	Zinc Calcium Sulphide
10 microsecond	Blue	Silver	Zinc Sulphide

image. This coil is placed on a funnel-shaped frame named Yoke. If one of these coils are used, coil frame scatters spot electron beam so that linear beam is produced on the plate. Passing current is not DC current and constant. This coil makes a inhomogeneous magnetic field but it has not special uses but the presence or absence of a inhomogeneous magnetic field can be felt by making electron beam linear and it can play role of second magnet in Stern-Gerlach experiment.

But using coil Yoke does not have scientific topicality in main experiment. And separating phenomenon seems Lorance phenomenon in the first view of viewer of its image. This issue is important, because it may cause incorrect perception of done experiment. Mentioned coil never use for making image in experiment. Since electrons have very higher thermal velocity than ions remove sooner and plasma with positive charge remains. So, plasma must have more positive plasma than wall.

Wall potential does not affect all plasma environment, Debye shieling limits potential change to layer with thickness of such Debye length. This layer which must be on all cold walls contacting with plasma named sheath. Sheath forms potential barrier which traps types with more motion (electron) in form of electrostatic. To separate electrons from filament and make them parallel with cathode which is far from anode, presence of grid voltages are inevitable and lack of them causes intensive scattering in electron beam. Photocathode is plate on which silver and Cesium with special array. When free electron reaches this plate, it causes fluorescence radiation.

When free electron beam reaches fluorescence plate of image, it produces a bright spot in the collision point because the effect of light reached eyes remains 1-ten second. Deviation resulting from noise made in escape plate cannot appear as fluctuating spot when it causes another beam to be seen. However, it is necessary that all grid plates have suitable and constant voltage and system is designed in such way that noise-accepting decreases. So it is necessary that image plate is covered with especial material from inside which firstly can convert received electric energy to light and secondly the its light resistance becomes more than one-ten second so that its effect remains in eyes during watching plate.

Such material is well known as Luminance which is divided into two parts: Fluorescence and Phosphorescence. Fluoresance is type of luminance which loses its brightness after removing the stimulus factor. If fluorescenceis type of luminance which maintain its light scattering after removing stimulus factor, so suitable Phosphorescence material is used to cover the lamp plate.TableII Unfortunately these two materials sometimes are confused. To make image plates of television, composition of sulphide zinc and zincberyllium silicate are used. Because these compositions have highest effect on converting electeric energy to light energy. Selecting type of image plates used is most important.

In television image lamp, cathode voltage is altering, so electrons will be scattered toward plate , however, electron beam remain more than 0.1 second in each point of plate while scattering its light energy will be 200 to 300 microsecond. All electeric energy do not convert to light one during colliding with image plate. Wasted energy as result of thermal effect is as follows: 50% of light returns into lamp and 20% of it breaks in internal level of lamp and 30% is used to show the image condition. So, what is seen is 30% of remained energy seen as light energy.

If light beam is transferred from one path to another, some of its energy is lost that this issue is very important when inhomogeneous magnetic field exerts free electron beam. In experiment, the effect of beam reflection must be remove. Inside the lamp, trumpet-shaped part of lamp is design and its internal walls are covered by profit material. Profit cover neutralize secondary electron reaction. If free electron fails to reach image plate and is not absorbed, the number of these electrons increases over time and their interaction with electron beam prevents electron beam from reaching image plate.

So, to remove free electron effect, metal plate or frame adjoined ground is used. This metal sheet is very thin and prevents the effect of interfering secondary electrons. It is shiny and is seen in the back of image lamp.

Note that using this metal sheet is a standard in technology of producing image lamp. It does not prevents from forming hale because its thickness is about $\approx 3.5 \times 10^{-5}$ cm and electrons can pass through such sheet. Hale conception in image lamp is understand when free electron beam collides with image plate and a set of bright hoop is seen on the image plate Figure5 and it is called hale.

FIG. 5: It shows the image of electrons band in which halo effect is seen. This effect is only removed by fixed voltage and current.

This hale is appeared due to light reflection in phosphrence of internal level of lamp and its break in image glass. Technically, whatever hale decreases, transparency of image increases, of course increasing transparency of image can be obtained by making free electron beam parallel and equalizing voltage of grid plate. Selecting flat image plate decreases hale. However, distributing free electron beam on image plate will be Gaussian distribution. Selecting and regulating suitable voltage is very effective to distribute free electron beam. Regulating camera is more important than distribution. The feeding source of DC voltage in image; amp circuits is provided according to frequency of electricity.

However, using capacitor with high electric capacity, transparency is done well. Equalizer high voltage consists of six diodes and five capacitors which are in a frame in form of CASCODE so it is called CASCODE equalizer. To limit high voltage current , resistance 47 kilo ohm is used near of cable opening of high voltage. Changes and fluctuations of electricity do not have high effect on feeding source of image systems because feeding circuits have several reinforcing classes that if one of these classes damages , other classes causes it to have final constant voltage.

The presence of fuse resistance in feeding circuits causes other parts not to damage if one part damages. By decreasing high voltage image intensification and

(a)

(b)

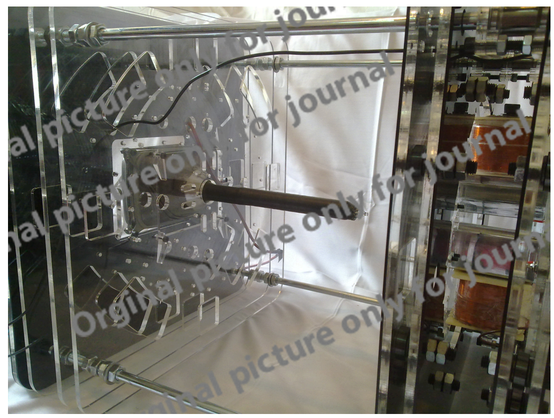


FIG. 6: The figure shows the system diagram. It shows the magnets of Stern-Gerlach experiment by free electron , magnets must be placed and set in suitable spatial situations. They can be set in suitable angle.

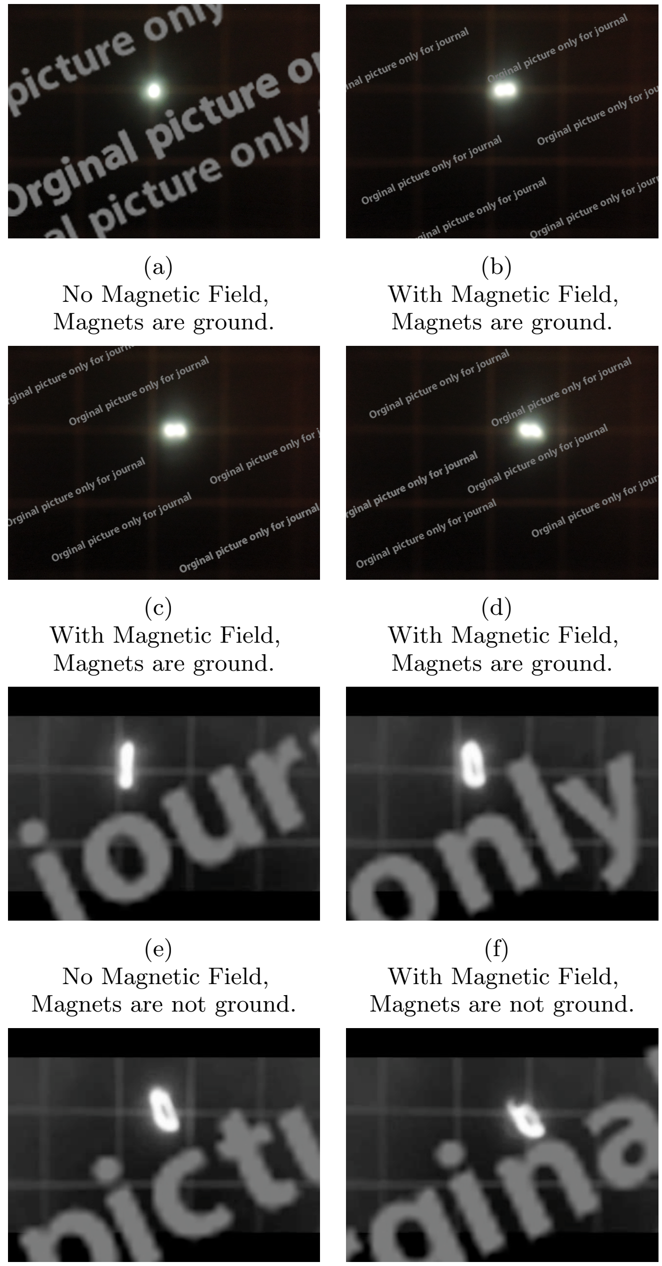
its transparency decrease if the velocity of free electron considerably decreases. If electrons velocity increases, scattering secondary electrons increases. But if electrons velocity is more than number, the brightness of image plate does not change and image intensification remains constant. However, the velocity of electron beam can be estimated by having image intensification. By changing cathode voltage in electron gun, image brightness intensification is controlled, cathode current is constant and is about milli-amper. Now, the used structure in the experiment is introduced Figure6.

The most important part of system is a lamp which has high vacuum and is installed on constant form. Magnets producing inhomogeneous magnetic field are assembled on movable frame and they can be regulated in each angle Figure 4,6. As mentioned before, external wall is adjoined to ground to remove environmental effects and plasma sheath ones. To separate negative ions, cathode angle is regulated by special angle toward main path of electron motion.

To equalizing free electrons beam, voltage of grid plates is constant. Changes made in lamp in this experiment differs from usual lamp. Necessary electeric field must be DC and flat. These changes is done in such a way that needed physical conditions is implemented in experiment. To investigate Lorance force, two flat magnet can be used. Placing, distance and conditions of magnet are important in observed results. According to this issue that producing flat and ideal magnet field in weak magnet field is difficult and produced magnetic field constantly is inhomogeneous.

To make a flat and homogeneous magnetic field, it is better to increase the magnet distances. It is necessary to note the state of separating electrons beam. If flat magnets is in vertical direction, and separating is in horizontal one, separating results from Lorance force and if distance and intensification of flat magnets field is in such a way that produced magnetic field is inhomogeneous in vertical direction and there is separation in horizontal direction, this separation can not result from Lorance force and is the spin separation.

Experimental observation done by produced magnetic field from constant magnet or coil with DC current shows that electrons beam is affected by Lorance force and transferred by exerting flat magnetic field and there is no separation. As mentioned in published paper Ref[1], separations seen if inhomogeneous magnetic field is made by sharp pointed magnet. Produce source of its magnetic field can be constant magnetic or coil with DC current.Figure7.



(a) No Magnetic Field, Magnets are ground.

(b) With Magnetic Field, Magnets are ground.

(c) With Magnetic Field, Magnets are ground.

(d) With Magnetic Field, Magnets are ground.

(e) No Magnetic Field, Magnets are not ground.

(f) With Magnetic Field, Magnets are not ground.

(g) With Magnetic Field, Magnets are not ground.

(h) With Magnetic Field, Magnets are not ground.

FIG. 7: The figure shows the move state of the electrons beam when electrons are affected by inhomogeneous magnet field both in adjoin of magnets to ground and non-adjoin them to ground.

XIII. RESULTS

In this paper, theoretical adaptation and experimental observations obtained by Stern Gerlach experiment on free electrons are investigated. These evidences show that two factors of thermal velocity and velocity resulting from electeric field play main role in electrons velocity. When hot tungsten in lamp is affected by electeric field and is thrown toward fluorescence plate, electrons simply separate from tungsten. If there is no electeric field, electrons can only move around tungsten due to low mass and they don't have enough to collide with fluorescence plate. Commonly, an altering electric current issued to heat tungsten, but it is cannot be used in this experiment.

According to very thin level of tungsten wire and milli-amper electeric current passing it, the thin wire of tungsten can be heated by a constant electeric voltage and current. Thermal velocity of electrons is from $\approx 10^4[\frac{m}{s}]$ to $\approx 10^5[\frac{m}{s}]$ if it only results from hot tungsten. If electrons velocity only results from electeric field, electron velocity will be from $\approx 10^4[\frac{m}{s}]$ to $\approx 10^6[\frac{m}{s}]$ (this velocity order from hot tungsten,this order is not of electeric field order.Notice that in low voltage only you can see this phenomenon).

This experiment have two main thermal effect, one of them is tungsten temperature. other thermal effect is plasma temperature that makes by high voltage. when voltage is very low the order term of plasma temperature same as tungsten temperature,It has very low temperature. Tungsten have a main role in this experiment and it is very important and velocity of free electrons depend to this order. in action you can see this parameter is very important.

According to mentioned issues in Langmuir probe experiment. However, final velocity of electron is sum of thermal velocity of electron and velocity resulting from electeric field. What is seen in practice shows that if voltage is higher, electron beam has its highest magnitude and velocity resulting from electeric field is dominant one in final velocity of free electrons.But when high voltage decreases, dominant component in final velocity of electrons is not the velocity resulting from electeric field. The velocity resulting from electeric field decreases and approaches thermal velocity and prevents their fast waste of electrons thermal velocity by decreasing voltage of electeric field and it provides necessary force for electrons to move path.

As mentioned, magnetic field gradient needed is very low in low velocity.but you must make high magnetic field by very keen magnet Ref[1].It is very important that velocity in action be very low,It is possible in low voltage. it may be seems ionic velocity. please attention by some metod in gun and ... the negative ions was removed in gun and ...Also the last calculations are only for a single electron but in the large scale of free electrons the problem is very different....

According to the last article[1] showed that it can make very keen magnet and by this method when the radius of keen magnet is nano-meter in Equation64, It maybe help to see this phenomenon in action. When used magnetic is sharp, spin separation of free electron occurs in practice and is observable. By changing DC voltage of electric field, separation distance changes.At this experiment used only by DC voltage and stationary magnets.

If magnetic does not adjoin the ground Figure7 , single beam is seen as straight line . By exerting inhomogeneous magnetic field, separation is seen as a hoop which moves in direction of Lorance by increasing magnetic field. This clearly shows that observed separation does not results from Lorance force..

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TABLE III: Shows the values of voltage, velocity, mass, energy.

Voltage ($Volt$)	**Velocity of Electrons** (m/sec)			**Mass of Electrons** (Kg)			**Energy of Electrons** ($N.m$)		
	Newtonian	*Einsteinian*	*Difference*	*Newtonian*	*Einsteinian*	*Difference*	*Newtonian*	*Einsteinian*	*Difference*
10	1.88E+06	1.88E+06	-2.75E+01	9.11E-31	9.11E-31	1.78E-35	1.60E-18	1.60E-18	3.13E-23
100	5.93E+06	5.93E+06	-8.70E+02	9.11E-31	9.11E-31	1.78E-34	1.60E-17	1.60E-17	3.13E-21
200	8.39E+06	8.38E+06	-2.46E+03	9.11E-31	9.11E-31	3.56E-34	3.20E-17	3.21E-17	1.25E-20
300	1.03E+07	1.03E+07	-4.52E+03	9.11E-31	9.11E-31	5.35E-34	4.81E-17	4.81E-17	2.82E-20
400	1.19E+07	1.19E+07	-6.96E+03	9.11E-31	9.12E-31	7.13E-34	6.41E-17	6.41E-17	5.02E-20
500	1.33E+07	1.33E+07	-9.72E+03	9.11E-31	9.12E-31	8.91E-34	8.01E-17	8.02E-17	7.84E-20
600	1.45E+07	1.45E+07	-1.28E+04	9.11E-31	9.12E-31	1.07E-33	9.61E-17	9.62E-17	1.13E-19
700	1.57E+07	1.57E+07	-1.61E+04	9.11E-31	9.12E-31	1.25E-33	1.12E-16	1.12E-16	1.54E-19
800	1.68E+07	1.68E+07	-1.97E+04	9.11E-31	9.12E-31	1.43E-33	1.28E-16	1.28E-16	2.01E-19
900	1.78E+07	1.78E+07	-2.35E+04	9.11E-31	9.13E-31	1.60E-33	1.44E-16	1.44E-16	2.54E-19
1000	1.88E+07	1.87E+07	-2.75E+04	9.11E-31	9.13E-31	1.78E-33	1.60E-16	1.61E-16	3.13E-19
2000	2.65E+07	2.64E+07	-7.76E+04	9.11E-31	9.14E-31	3.56E-33	3.20E-16	3.22E-16	1.25E-18
3000	3.25E+07	3.23E+07	-1.42E+05	9.11E-31	9.16E-31	5.35E-33	4.81E-16	4.83E-16	2.82E-18
4000	3.75E+07	3.73E+07	-2.19E+05	9.11E-31	9.18E-31	7.13E-33	6.41E-16	6.46E-16	5.02E-18
5000	4.19E+07	4.16E+07	-3.05E+05	9.11E-31	9.20E-31	8.91E-33	8.01E-16	8.09E-16	7.84E-18
6000	4.59E+07	4.55E+07	-4.00E+05	9.11E-31	9.22E-31	1.07E-32	9.61E-16	9.72E-16	1.13E-17
7000	4.96E+07	4.91E+07	-5.03E+05	9.11E-31	9.23E-31	1.25E-32	1.12E-15	1.14E-15	1.54E-17
8000	5.30E+07	5.24E+07	-6.14E+05	9.11E-31	9.25E-31	1.43E-32	1.28E-15	1.30E-15	2.01E-17
9000	5.63E+07	5.55E+07	-7.31E+05	9.11E-31	9.27E-31	1.60E-32	1.44E-15	1.47E-15	2.54E-17
10000	5.93E+07	5.85E+07	-8.54E+05	9.11E-31	9.29E-31	1.78E-32	1.60E-15	1.63E-15	3.13E-17
20000	8.39E+07	8.15E+07	-2.37E+06	9.11E-31	9.47E-31	3.56E-32	3.20E-15	3.33E-15	1.25E-16
30000	1.03E+08	9.84E+07	-4.28E+06	9.11E-31	9.64E-31	5.35E-32	4.81E-15	5.09E-15	2.82E-16
40000	1.19E+08	1.12E+08	-6.48E+06	9.11E-31	9.82E-31	7.13E-32	6.41E-15	6.91E-15	5.02E-16
50000	1.33E+08	1.24E+08	-8.90E+06	9.11E-31	1.00E-30	8.91E-32	8.01E-15	8.79E-15	7.84E-16
60000	1.45E+08	1.34E+08	-1.15E+07	9.11E-31	1.02E-30	1.07E-31	9.61E-15	1.07E-14	1.13E-15
70000	1.57E+08	1.43E+08	-1.43E+07	9.11E-31	1.04E-30	1.25E-31	1.12E-14	1.28E-14	1.54E-15
80000	1.68E+08	1.51E+08	-1.71E+07	9.11E-31	1.05E-30	1.43E-31	1.28E-14	1.48E-14	2.01E-15
90000	1.78E+08	1.58E+08	-2.01E+07	9.11E-31	1.07E-30	1.60E-31	1.44E-14	1.70E-14	2.54E-15
100000	1.88E+08	1.64E+08	-2.32E+07	9.11E-31	1.09E-30	1.78E-31	1.60E-14	1.92E-14	3.13E-15
200000	2.65E+08	2.08E+08	-5.68E+07	9.11E-31	1.27E-30	3.56E-31	3.20E-14	4.46E-14	1.25E-14
300000	3.25E+08	2.33E+08	-9.20E+07	9.11E-31	1.45E-30	5.35E-31	4.81E-14	7.63E-14	2.82E-14
400000	3.75E+08	2.48E+08	-1.27E+08	9.11E-31	1.62E-30	7.13E-31	6.41E-14	1.14E-13	5.02E-14
500000	4.19E+08	2.59E+08	-1.61E+08	9.11E-31	1.80E-30	8.91E-31	8.01E-14	1.58E-13	7.84E-14
600000	4.59E+08	2.66E+08	-1.93E+08	9.11E-31	1.98E-30	1.07E-30	9.61E-14	2.09E-13	1.13E-13
700000	4.96E+08	2.72E+08	-2.24E+08	9.11E-31	2.16E-30	1.25E-30	1.12E-13	2.66E-13	1.54E-13
800000	5.30E+08	2.76E+08	-2.54E+08	9.11E-31	2.34E-30	1.43E-30	1.28E-13	3.29E-13	2.01E-13
900000	5.63E+08	2.79E+08	-2.83E+08	9.11E-31	2.52E-30	1.60E-30	1.44E-13	3.98E-13	2.54E-13
1000000	5.93E+08	2.82E+08	2.82E+08	9.11E-31	2.69E-30	1.78E-30	1.60E-13	4.74E-13	3.13E-13

TABLE IV: Shows the Momentum of Electrons and Wavelength of Electrons and Resolution.

Voltage ($volt$)	**Momentum of Electrons** ($N.sec$)			**Wavelength of Electrons** ($deBroglieEquation$)(m)			**Resolution** ($Abbe'sEquation$)(m)		
	Newtonian	*Einsteinian*	*Difference*	*Newtonian*	*Einsteinian*	*Difference*	*Newtonian*	*Einsteinian*	*Difference*
10	1.71E-24	1.71E-24	-6.94E-28	3.88E-10	3.88E-10	-1.90E-15	2.37E-08	2.37E-08	-1.16E-13
100	5.40E-24	5.40E-24	-2.43E-27	1.23E-10	1.23E-10	-6.00E-15	7.51E-09	7.51E-09	-3.67E-13
200	7.64E-24	7.64E-24	-3.81E-27	8.67E-11	8.67E-11	-8.48E-15	5.31E-09	5.31E-09	-5.19E-13
300	9.36E-24	9.36E-24	-5.12E-27	7.08E-11	7.08E-11	-1.04E-14	4.33E-09	4.33E-09	-6.36E-13
400	1.08E-23	1.08E-23	-6.45E-27	6.13E-11	6.13E-11	-1.20E-14	3.75E-09	3.75E-09	-7.34E-13
500	1.21E-23	1.21E-23	-7.80E-27	5.48E-11	5.48E-11	-1.34E-14	3.36E-09	3.36E-09	-8.21E-13
600	1.32E-23	1.32E-23	-9.19E-27	5.01E-11	5.01E-11	-1.47E-14	3.06E-09	3.06E-09	-8.99E-13
700	1.43E-23	1.43E-23	-1.06E-26	4.64E-11	4.63E-11	-1.59E-14	2.84E-09	2.84E-09	-9.71E-13
800	1.53E-23	1.53E-23	-1.21E-26	4.34E-11	4.33E-11	-1.70E-14	2.65E-09	2.65E-09	-1.04E-12
900	1.62E-23	1.62E-23	-1.36E-26	4.09E-11	4.09E-11	-1.80E-14	2.50E-09	2.50E-09	-1.10E-12
1000	1.71E-23	1.71E-23	-1.52E-26	3.88E-11	3.88E-11	-1.90E-14	2.37E-09	2.37E-09	-1.16E-12
2000	2.42E-23	2.42E-23	-3.33E-26	2.74E-11	2.74E-11	-2.68E-14	1.68E-09	1.68E-09	-1.64E-12
3000	2.96E-23	2.96E-23	-5.52E-26	2.24E-11	2.24E-11	-3.28E-14	1.37E-09	1.37E-09	-2.01E-12
4000	3.42E-23	3.42E-23	-8.04E-26	1.94E-11	1.94E-11	-3.78E-14	1.19E-09	1.18E-09	-2.32E-12
5000	3.82E-23	3.83E-23	-1.09E-25	1.73E-11	1.73E-11	-4.23E-14	1.06E-09	1.06E-09	-2.59E-12
6000	4.18E-23	4.20E-23	-1.39E-25	1.58E-11	1.58E-11	-4.63E-14	9.69E-10	9.66E-10	-2.83E-12
7000	4.52E-23	4.54E-23	-1.72E-25	1.47E-11	1.46E-11	-4.99E-14	8.97E-10	8.94E-10	-3.06E-12
8000	4.83E-23	4.85E-23	-2.08E-25	1.37E-11	1.37E-11	-5.34E-14	8.39E-10	8.36E-10	-3.27E-12
9000	5.13E-23	5.15E-23	-2.45E-25	1.29E-11	1.29E-11	-5.65E-14	7.91E-10	7.88E-10	-3.46E-12
10000	5.40E-23	5.43E-23	-2.85E-25	1.23E-11	1.22E-11	-5.96E-14	7.51E-10	7.47E-10	-3.65E-12
20000	7.64E-23	7.72E-23	-7.74E-25	8.67E-12	8.59E-12	-8.36E-14	5.31E-10	5.26E-10	-5.12E-12
30000	9.36E-23	9.50E-23	-1.40E-24	7.08E-12	6.98E-12	-1.02E-13	4.33E-10	4.27E-10	-6.22E-12
40000	1.08E-22	1.10E-22	-2.13E-24	6.13E-12	6.02E-12	-1.17E-13	3.75E-10	3.68E-10	-7.13E-12
50000	1.21E-22	1.24E-22	-2.96E-24	5.48E-12	5.36E-12	-1.29E-13	3.36E-10	3.28E-10	-7.92E-12
60000	1.32E-22	1.36E-22	-3.88E-24	5.01E-12	4.87E-12	-1.41E-13	3.06E-10	2.98E-10	-8.62E-12
70000	1.43E-22	1.48E-22	-4.87E-24	4.64E-12	4.48E-12	-1.51E-13	2.84E-10	2.74E-10	-9.24E-12
80000	1.53E-22	1.59E-22	-5.92E-24	4.34E-12	4.18E-12	4.18E-12	2.65E-10	2.56E-10	-9.81E-12
90000	1.62E-22	1.69E-22	-7.04E-24	4.09E-12	3.92E-12	-1.69E-13	-1.69E-13	2.40E-10	-1.03E-11
100000	1.71E-22	1.79E-22	-8.22E-24	3.88E-12	3.70E-12	-1.77E-13	2.37E-10	2.27E-10	-1.08E-11
200000	2.42E-22	2.64E-22	-2.27E-23	2.74E-12	2.51E-12	-2.34E-13	1.68E-10	1.53E-10	-1.43E-11
300000	2.96E-22	3.37E-22	-4.07E-23	2.24E-12	1.97E-12	-2.70E-13	1.37E-10	1.20E-10	-1.65E-11
400000	3.42E-22	4.03E-22	-6.14E-23	1.94E-12	1.64E-12	-2.95E-13	1.19E-10	1.01E-10	-1.81E-11
500000	3.82E-22	4.66E-22	-8.43E-23	1.73E-12	1.42E-12	-3.13E-13	1.06E-10	8.70E-11	-1.92E-11
600000	4.18E-22	5.27E-22	-1.09E-22	1.58E-12	1.26E-12	-3.26E-13	9.69E-11	7.69E-11	-2.00E-11
700000	4.52E-22	5.87E-22	-1.35E-22	1.47E-12	1.13E-12	-3.37E-13	8.97E-11	6.91E-11	-2.06E-11
800000	4.83E-22	6.45E-22	-1.62E-22	1.37E-12	1.03E-12	-3.44E-13	8.39E-11	6.28E-11	-2.11E-11
900000	5.13E-22	7.03E-22	-1.90E-22	1.29E-12	9.43E-13	-3.50E-13	7.91E-11	5.77E-11	-2.14E-11
1000000	5.40E-22	7.60E-22	-2.20E-22	1.23E-12	8.72E-13	-3.54E-13	7.51E-11	5.34E-11	-2.17E-11