The study of plasma behavior by using electrostatic probes

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Abstract

The account of factors of plasma is one of the fundamentals of limited plasma. The disorder of plasma is caused by cognitive field .So these factors are accounted in the current for probe before adjusting it then accounted these factors after adjusting the probe current in the method of polynomial .The proportional mistake for each case is taken. It appeared that the tendency towards the confused area diminishes. So the accounted values for the factors of plasma resulted from the instability of the plasma and the current. It appeared that this method keeps the form of variety with Ψ/I and the proportional mistake becomes less by increasing Ψ/I.

الخلاصة

لقد تم حساب معلمات البلازما التي تعتبر من أساسيات البلازما المحصورة مغناطيسياً حيث إن الاضطراب الموجود في البلازما سببه المجال المغناطيسي ،لذا فقد تم حساب هذه المعلمات في مجس بحالة التيار للمجس قبل تعديله ومن ثم حساب معلمات البلازما بعد تعديل تيار المجس بطريقة polynomial كما تم اخذ الخطأ النسبي لكل حالة وقد تبين إن الاتجاه نحو المنطقة المضطربة يقل .

لذا فان القيم المحسوبة لمعلمات البلازما ناتجة من عدم استقرارية البلازما والتيار ،وقد تبين أن هذه الطريقة تحافظ على شكل التغاير مع Ψ/I وان الخطأ النسبي يكون قليل بزيادة Ψ/I .

Introduction

A Plasma is a quasineutral gas of charged and neutral particles which exhibits collective behavior [1] .A stratum of charged particles will cover any body placed inside the plasma and expose a behavior that prevent plasma from interaction with this body called ”plasma sheath”, it’s thickness is in Debye lengths.

The effort in the main body of plasma is about zero because of the semi proportional equation, but it increases in the cover area due to its capacity to pick up positive ions. When putting a pole which is electrically isolated inside the plasma, the number of electrons that collide with the pole through time is more than the number of ions because the hot speed of electrons is more than the hot speed of ions in most of plasma, so the accumulation of electrons on the surface of the pole will increase the negative electric effort for the surrounding plasma.

The effect of this effort will lead to accelerating positive ions and slowing down electrons moving towards it, so this will lead to increasing electric field and the whole electric current equals zero and is called “floating potential” ,the difference in effort between pole and plasma found in the cover area. The volume of the surrounding cover of the probe depending on the partiality voltage, the volume of probe and the physical characteristics of the plasma [2]

The Method

The probes have different designs like round, cylinder, they differ in design and application to account the plasma factors [3,4]

The density of ion and electron, the temperature of electron and the potential of plasma floating of plasma will be used these probes are called “Langmuir probes”. Improvements are made for manufacturing and designing of probes and increasing the efficiency of electronic equipments in order to obtain better performance of the probe .The technique used in measurement of plasma consists only of electric probes, double probe, since the plasma is unstable when it is magnetically limited, so modifying the current of the probe will be taken into consideration. Magnetic field is used to limit plasma; its strength is nearly (0.03T) which has little effect on the measurement of the ion current [5]

The part which is analyzed in the curved of current and the potential is the ion part where "radius larmur" is great as compared to the radius of the probe and "Debye length".

The factors of plasma are accounted as follows:

1. The density of ions: in the case of the cold ion $\frac{e\Delta\emptyset}{KTi} \gg 1$, then the temperature of ion (Ti) is less than the temperature of electron (Te):

$$I_i = \left(\frac{An\infty e}{\pi}\right)\left(\frac{2e\Delta\mp}{m_i}\right)^{\frac{1}{2}}$$

Where ($\Delta\emptyset$) the probe potential, I_i the ion current,(K) Boltzmann's constant ,(mi) mass of ion,(A)the surface area of probe and (n∞) the density for far distances from the sheath.

The formula represents the current of ion saturation, the density of ion depends only on $\left(\frac{I_i}{\phi_p}\right)^{\frac{1}{2}}$,so $(I_i)^2$ next to the probe potential Δϕ will be :

$$\frac{I_i^2}{\Delta\emptyset} = \left(\frac{An_i e}{\pi}\right)^2 \left(\frac{2e}{n_i}\right)$$

Where (ni) the density of ions.

The relation above will give a straight line [6], by counting the degree of tendency of this straight line; we get the density of ion n_i the represented with the plasma density.

2.The potential of plasma: it represents the point of which the ion current I_i vanishes .The saturation line intersect with the axis of highlighted potential at the point of potential of plasma ,so the potential of plasma represents the required potential of probe to make the probe current an electronic current (I_e) ,i.e.

$$\phi_s = \phi + \phi_f$$

Where ϕ_s the potential of space, ϕ_f the floating potential

3. The temperature: The distribution of electrons represented by the distribution of Maxwell for velocity.

$$I_e = en_\infty A\left(\frac{KT_e}{2\pi n_i}\right)^{\frac{1}{2}} e^{-(e\Delta\emptyset/KT_e)}$$

$$I_e = I_{es}e^{-(e\Delta\emptyset/KT_e)}$$

$$lnI_e = lnI_{es} - \left(\frac{e\Delta\emptyset}{KT_e}\right)$$

Where I_{es} represents electronic current at Φ_s and next to Φ will produce a straight line its tendency gives the temperature of electron.

4. The sheath potential (α): the sheath potential ratio of the probe depends on the ratio of the density of edge of sheath which is stable according to Bohm criterion approximation [7], and on the ratio of density of ion gas so:

$$\alpha = \left(\frac{\Phi_s - \Phi_f}{T_e}\right)$$

Conclusion and discussion:

The factors of plasma are counted which is considered as fundamentals in the magnetically limited plasma and which represent ion density(Ni), electron temperature (Te) and the potential plasma (Φ_s) by using different positions for the double probe .Many researchers have found these factors in many processes in different positions in the system(8,9,10,11),so the interior and mutual areas the edge of plasma.

A-The ionic current before modification:

The figure (1) shows the derivative for the square of current as function of potential at value(Ψ/I=0.05),it shows the instability in the value of derivative which resulted from the instability of the values of current and sensitive program in counting the derivative .There is tendency towards type of stability in the area between (4V) and (10V)it's tendency is lower ,so the curved ,which continues the figure ,represents a better multi basis correspondence for the extracted values ,from this curved ,the range for linear limited the value of potential between (4-10V) can be decided.

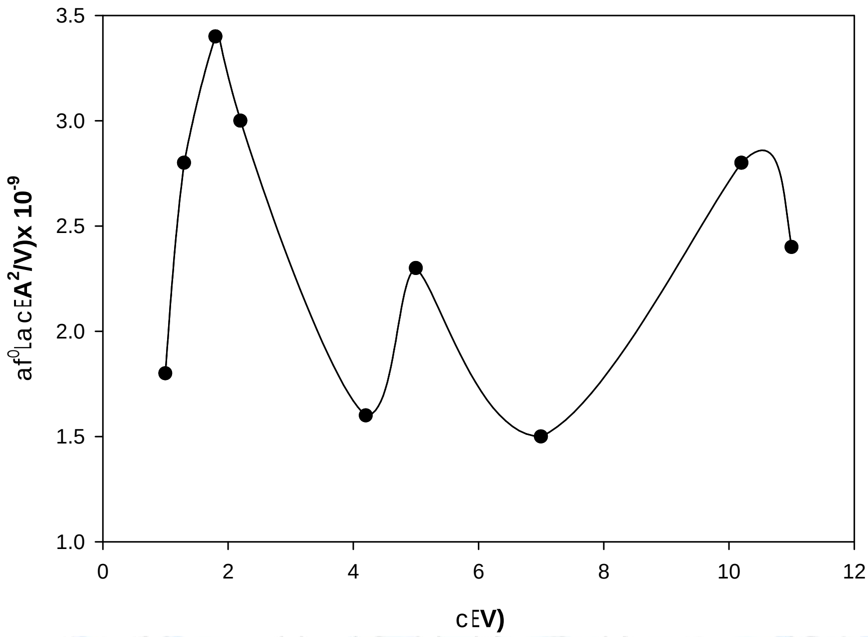

Fig (1) the derivative for the square of current as function of potential at value (Ψ/I=0.05)

Figure (2) represents the derivative for the square of current as a function of potential at the value (Ψ/I=0.35),there is instability in the values of derivation which belongs also great instability in the values of current because the area is instable originally and the sensitivity of the program in counting the derivative .There is also tendency towards type of stability of the value in the area between (0.3V)and (0.8V) ,these area has lower tendency and the curved continues on the figure represents a better multi basis correspondence for to extracted values so we can decide the range for the line relation limited between(0.3V) and(0.8V).

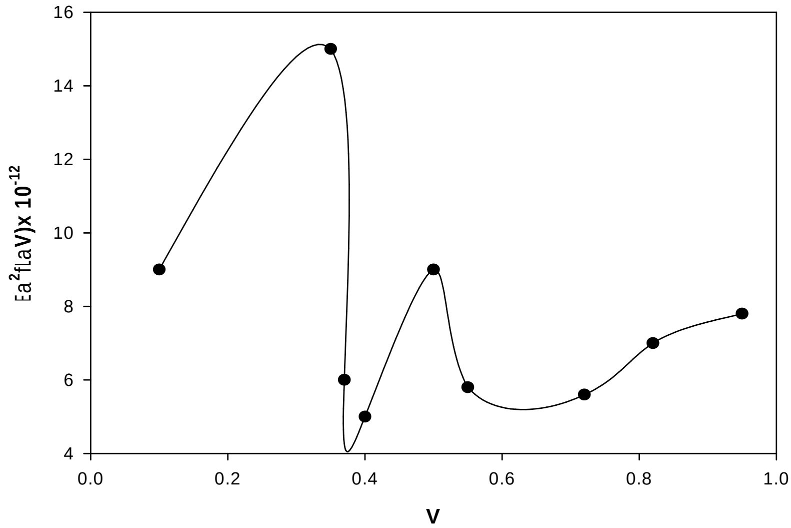

Figure (2) the derivative for the square of current as a function of potential at the value (Ψ/I=0.35)

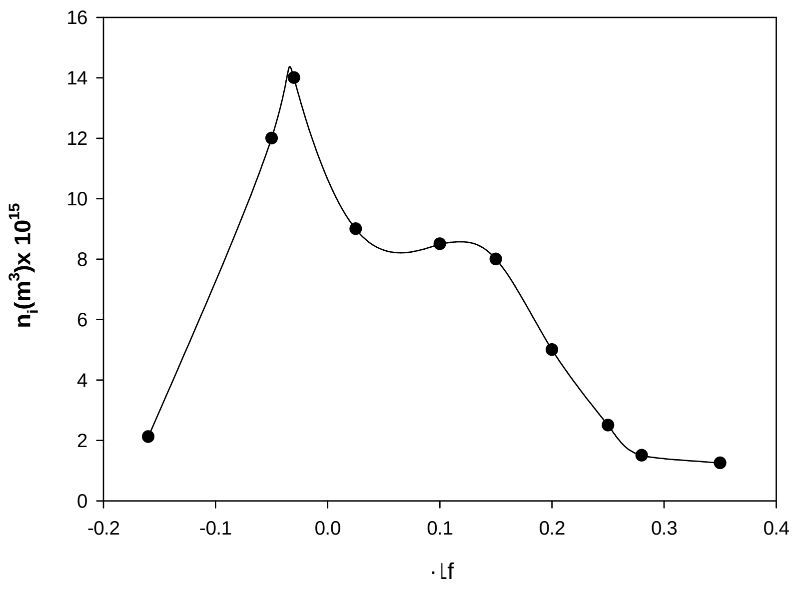

Figure (3) ionic density as function for the values Ψ/I

Figure (3) shows ionic density as function for the values Ψ/I ,also the figure (4) shows temperature of electron , figure (5) shows the potential of plasma .All these figures are taken as function Ψ/I and in limit values which include points inside grave surface by observing the three figures ,we find the curved that we obtained agrees with what tackled before .Other researchers found [8,9,10,11], using standard double probe.

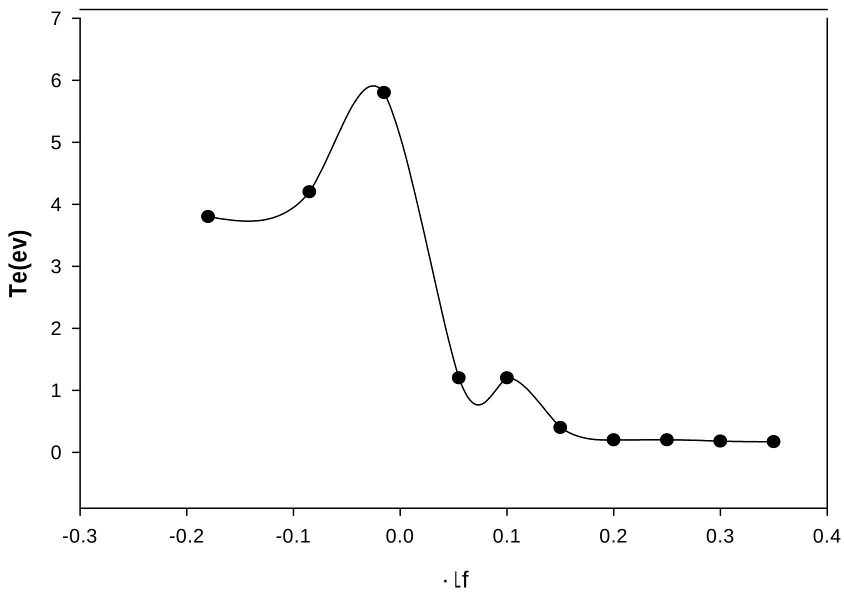

Figure (4) the temperature of electron as function for the values Ψ/I

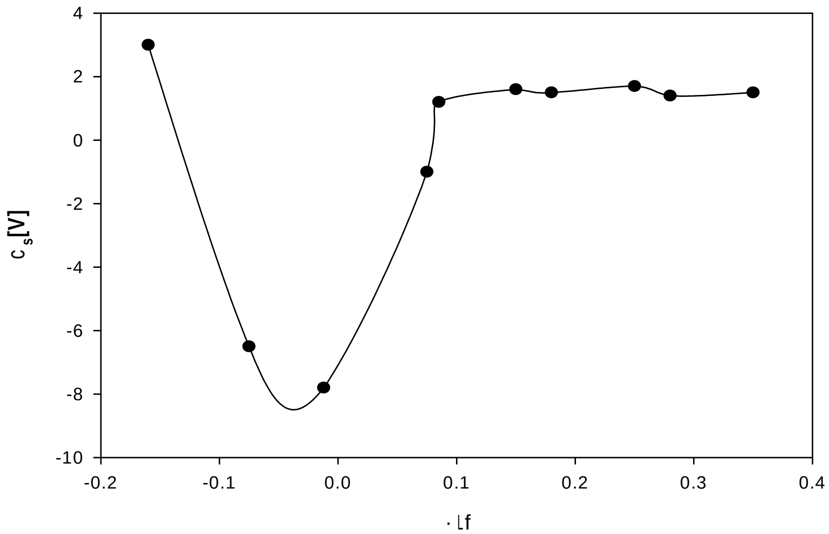

Figure (5) the potential of plasma as function for the values Ψ/I

Figure (6) shows the values α for areas inside and outside the grave surface .It shows that α changes in the interior areas of plasma .Many papers discussed the traits and properties (8,9,12),,there is an effect of the wall of the mineral vessel on the counts α [13] .

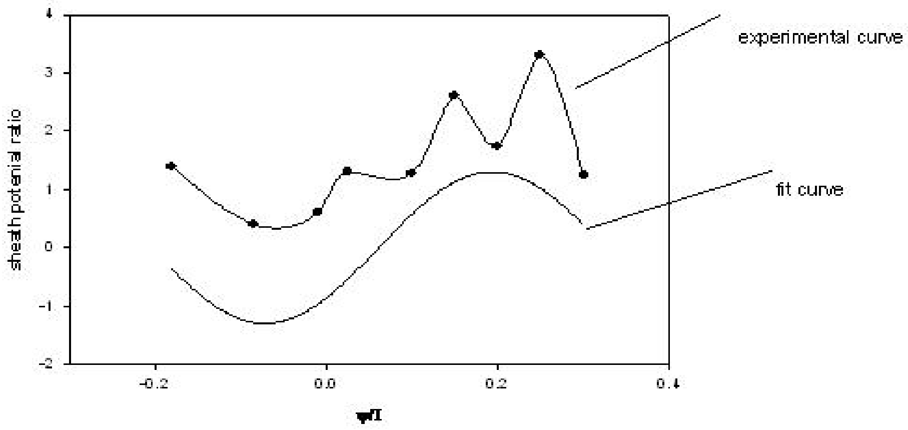

Figure (6) the values α for areas inside and outside the grave surface

B-The ionic current after modification:

The current of probe I(ϕ) in magnetically limited plasma and because of the confusion in plasma will change and instable through time. This change is arbitrary when we consider ϕ a stable quantity so the current is modified, and the derivative is taken for square of current to the potential at the value (Ψ/I=0.05) as in figure (7) .The continued curved on the figure represents a better multi basis correspondence for the extracted values, so we can decide the range for the line relation limited for the potential values between (4V, 10V).

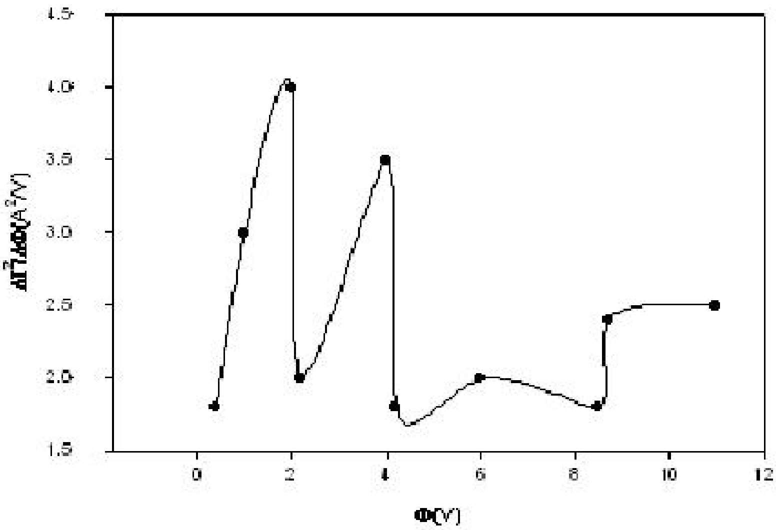

Figure (7) the derivative for the square of current as function of potential at value (Ψ/I=0.05)

Figure (8)includes the square of current as function of potential at(Ψ/I=0.35) and the curved continued on figure represents a better multi basis correspondence for the extracted values ,so we can decide the range of the line relation limited for potential values between (0.3-0.8V).

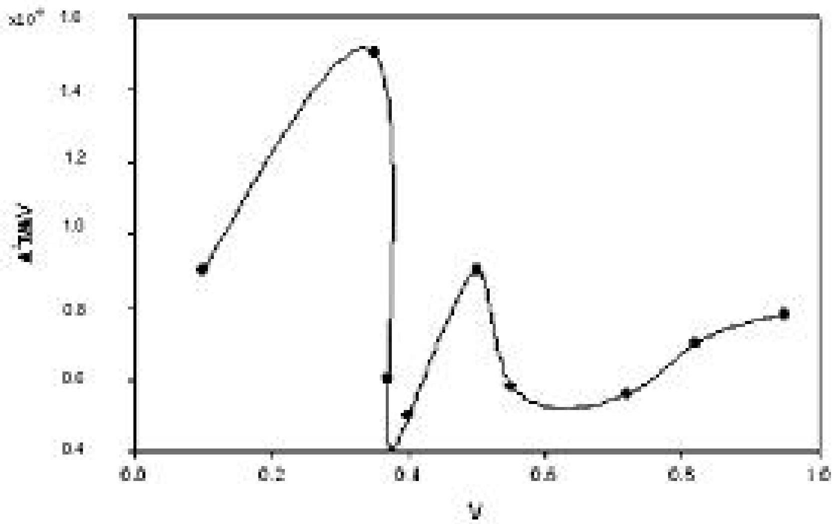

Figure (8) the square of current as function of potential at(Ψ/I=0.35)

After modification of current, we count factors of plasma again which is the basis of limited plasma represented by ionic density ni, temperature of electron Te and the potential of plasma Φ_s .

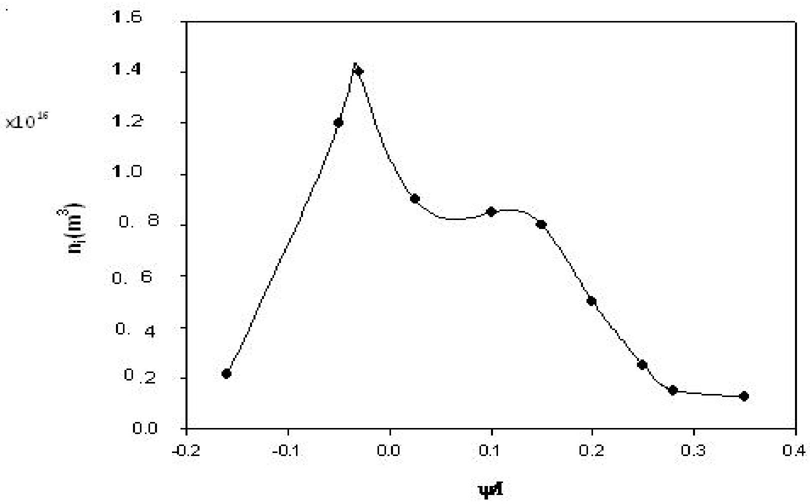

Figure (9) ionic density as function for (Ψ/I)

Figure (9) shows ionic density, figure (10) temperature of electron, figure (11) shows potential of plasma, these figures are as function for (Ψ/I) in limit values include points inside and outside the grave surface.

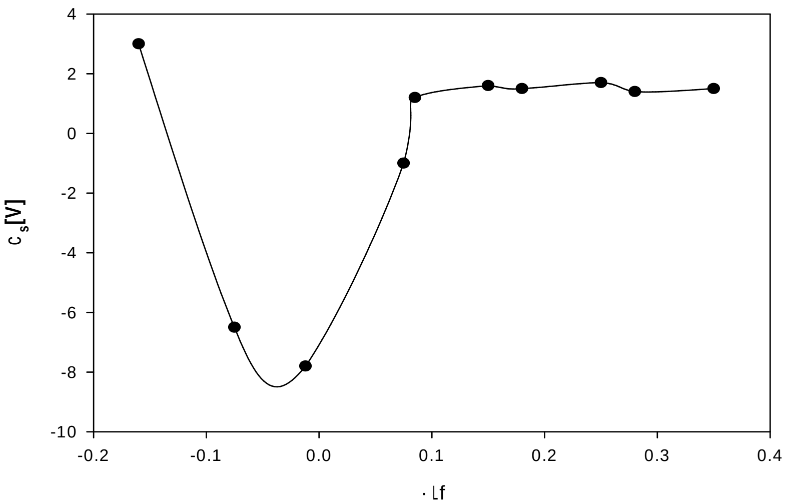

Figure (10) temperature of electron as function for (Ψ/I)

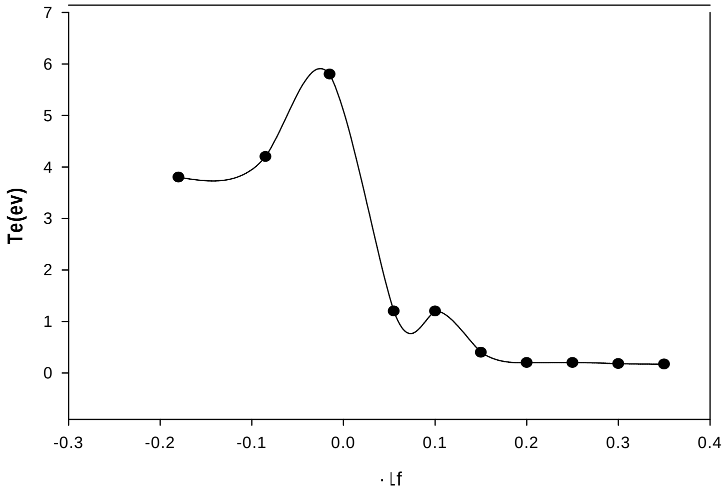

Figure (11) potential of plasma as function for (Ψ/I)

It becomes clear from these figures that there is no difference with the former figures before modifying the current. So we can conclude that the factors curved, before and after modification, keep the form of variety with area Ψ/I and the ratio method will be suitable.

Depending on the values above and after modifying the current, we count α, figure (12) shows the value of α after modification for areas inside and outside the grave surface .It is noticed through the figure that there is no disparity with what has been found in α before modification, so the ratio method is also suitable.

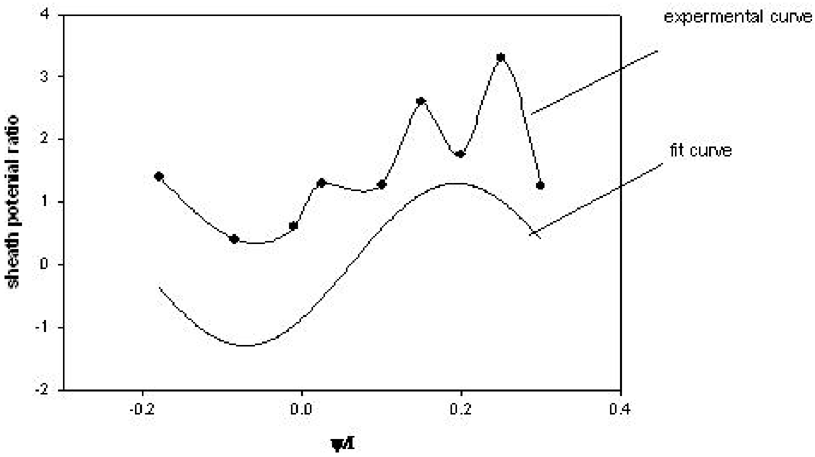

figure (12) the value of α after modification for areas inside and outside the grave surface

The proportional mistake in the factors of plasma before and after modification is found by using method of (polynomial) in different degree.

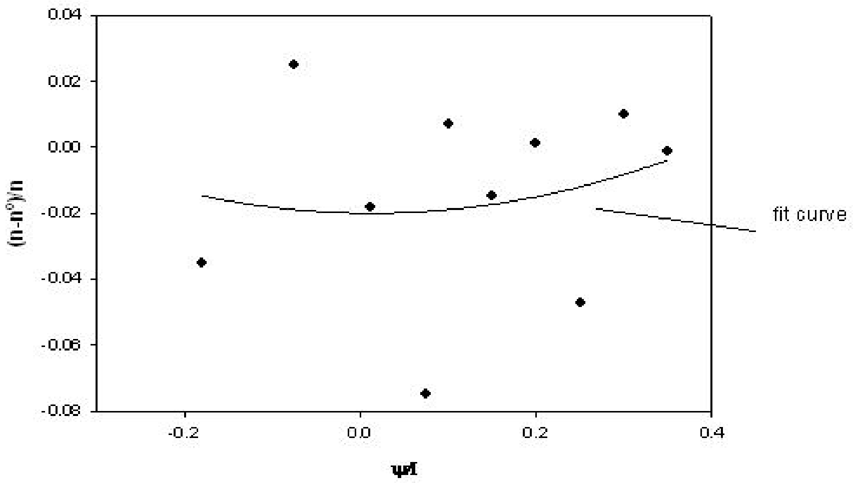

Figure (13) shows the proportional mistake of density (n-n0/n)

Figure(13) shows the proportional mistake of density (n-n0/n),where (n) represents ionic density before modification and (n0) represents ionic density after modification .By observing the figure ,we find mistake in density specially in instable areas ,so the average method is not efficient in measuring density and it should be improved [14].

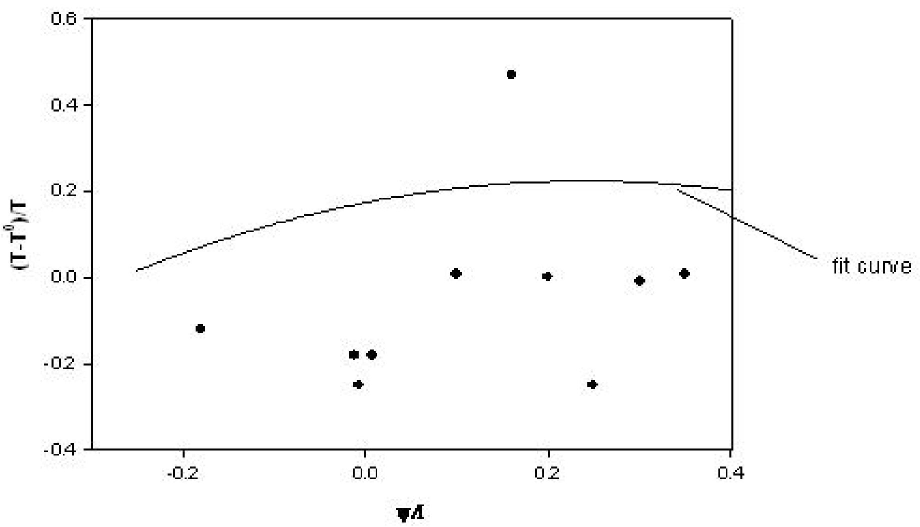

Figure (14) shows the proportional mistake in temperature (T-T0/T)

Figure (14) shows the proportional mistake in temperature (T-T0/T) .T represents temperature of electron before modification,(T0) represents temperature of electron after modification. From the figure, we notice that the ratio of mistake is little specially in the confusion area which denotes the success of average method specially the area itself.

Figure (15) shows the proportional mistake in potential of plasma ($\phi_s - \phi_s{}^0/\phi_s$) the ratio of mistake is little specially in the instability area which denotes the success of average method in that area, so the proportional mistake decreases when area of (Ψ/I) increases.

The preoperational mistake decreases when going to the confusion area as compared to the stable area, so the average method is preferred when going to the confusion area.

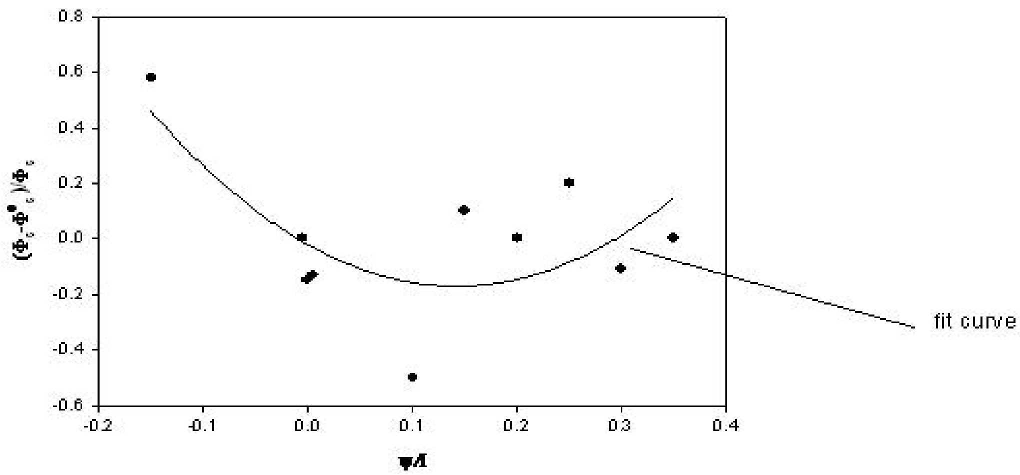

Figure (15) shows the proportional mistake in potential of plasma ($\phi_s - \phi_s{}^0/\phi_s$)

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