# Lab1 Problem 4: Deflection of Electron Beam by an Electric Field

Rui Zuo

Oct 6,2016

Physics 1302W Professor:Clement Pryke TA: Saumitran Kasturirangan

## Abstract

The deflection of an electron caused by electric field with a stable initial velocity was determined. The predicted distance deflected by the electric field was determined. The equation of defection and electric field is calculated out.

## Introduction

To design an accurate electron microscope, understanding the real effect from an electric field on an electron is very essential. So the aim of this experiment is to determine the effect of and electric field on and deflected electron. By measuring the deflected distance of the electron beam under different electric field the aim of the experiment could be achieved.

## Prediction

Mathematically, the predicted deflection distance of the electron beam will be affected under a stable electric field.

$$\Delta y = \Delta y_{in\ plate} + \Delta y_{out\ of\ the\ plate}$$

$$\Delta y_{in\ plate} = \frac{1}{2} a t_0^2 = \frac{Eql_0^2}{2mv_0^2} \qquad \Delta y_{out\ of\ the\ plate} = v_1 t_1 = \frac{Eql_0 l_1}{mv_0^2}$$

E is the magnitude of the electric field, q is the charge of an electron, m is the mass of an electron, v0 is the initial velocity of the electron, $l_0$=2cm is the length of the electric field plates, $l_1 = 7.4cm$ is the distance between the end of the plates and screen.

Since $V_0 = \sqrt{\frac{2V_{acc}q}{m}}$ and E=$\frac{V_{plates}}{d}$ $\quad \Delta y_{total} = \frac{V_{plates} l_0 (l_1 + \frac{l_0}{2})}{2v_{acc}d}$

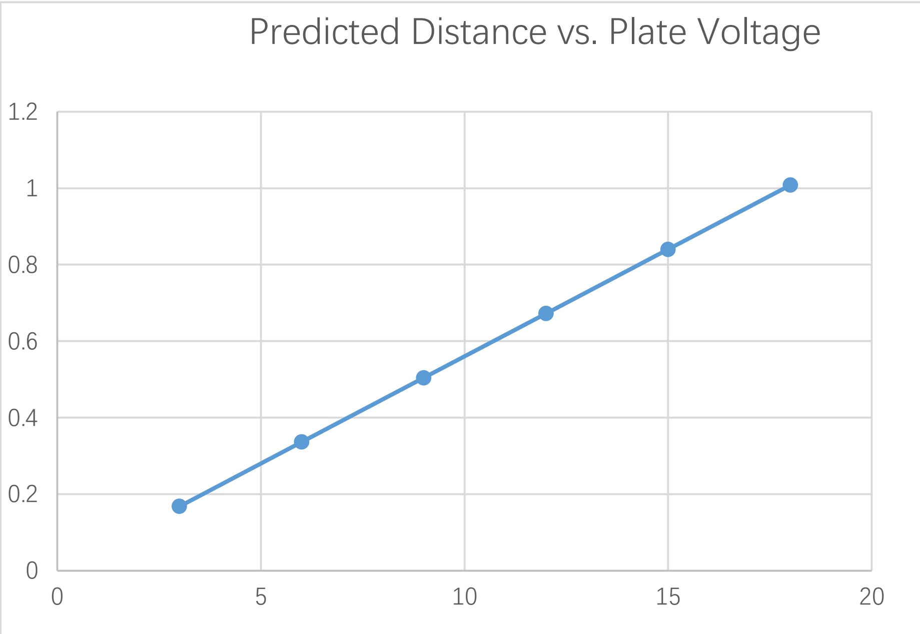
d=0.3 is the distance between two plates. $V_{plates}$ is the deflection voltage between two plates. $V_{acc}$ is the accelerating voltage which gives the electron initial speed.

## Procedure

Already we have known the distance between tow plates, the length of the plate and the distance between the end of the plates and the screen. Now we turned on the accelerating field with a constant which is 250V or 500V, recording the current location of the spot in the screen. Then we turned on the deflection electric field and measured position of the spot. We varied the deflection electric field and recorded the relative location of spot keeping the accerating field stable. All this data recorded will support us for the further analysis.

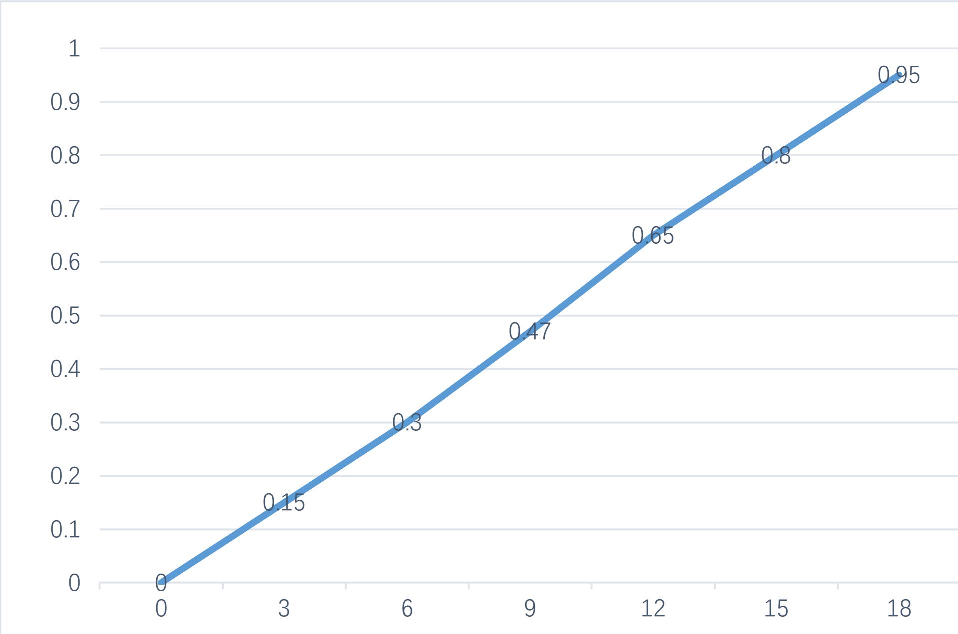
| $V_{acc}$(Volt) | $V_{plates}$(Volt) | $\Delta y_{predicted}$(cm) |
|---|---|---|
| 500 | 0 | 0 |
| 500 | 3 | 0.168 |
| 500 | 6 | 0.336 |
| 500 | 9 | 0.504 |
| 500 | 12 | 0.672 |
| 500 | 15 | 0.84 |
| 500 | 18 | 1.008 |

Table1:This table is built with three sets: the accelerating voltage ,the voltage between two plates and the predicted deflection distance




| Vacc(Volt) | Vplates(Volt) | $\Delta y_{measured}$(cm) |
|---|---|---|
| 500 | 0 | 0 |
| 500 | 3 | 1.5 |
| 500 | 6 | 3 |
| 500 | 9 | 4.7 |
| 500 | 12 | 6.5 |
| 500 | 15 | 8 |
| 500 | 18 | 9.5 |

Table 2: This table is built under 3 sets, the acceleration voltage, the voltage between two plates and the measured deflection distance.




Analysis:

During this experiment, The gravity of electron could be ignored. Since the magnitude of $\mathbf{G}_{electron} = m_{electron} \times g$ is about $10^{-29}$ N, the magnitude of $\mathbf{F}_{electric} = \frac{V_{plates} \times q}{d}$ is about $10^{-15}$ N and $\mathbf{G}_{electron} \ll \mathbf{F}_{electric}$.The table1 and table 2 give the predicted deflection distance and measured deflection distance separately. There is no exited in the measurement of $\mathbf{V}_{plates}$.

| $V_{plates}$(Volt) | $\Delta y_{measured}$(cm) | $\Delta y_{predicted}$(cm) | $d_{relative}$ | Deviation |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 3 | 0.15 | 0.168 | 10.7% | 0.018 |
| 6 | 0.3 | 0.336 | 10.7% | 0.036 |
| 9 | 0.47 | 0.504 | 1.4% | 0.034 |
| 12 | 0.65 | 0.672 | 3.3% | 0.022 |
| 15 | 0.8 | 0.84 | 4.8% | 0.040 |
| 18 | 0.95 | 1.008 | 1.3% | 0.013 |

Table 3: This table is built under 4 sets. The deflection voltage, the measured deflection, the predicted deflection and the relative difference between predicted deflection and the predicted deflection.

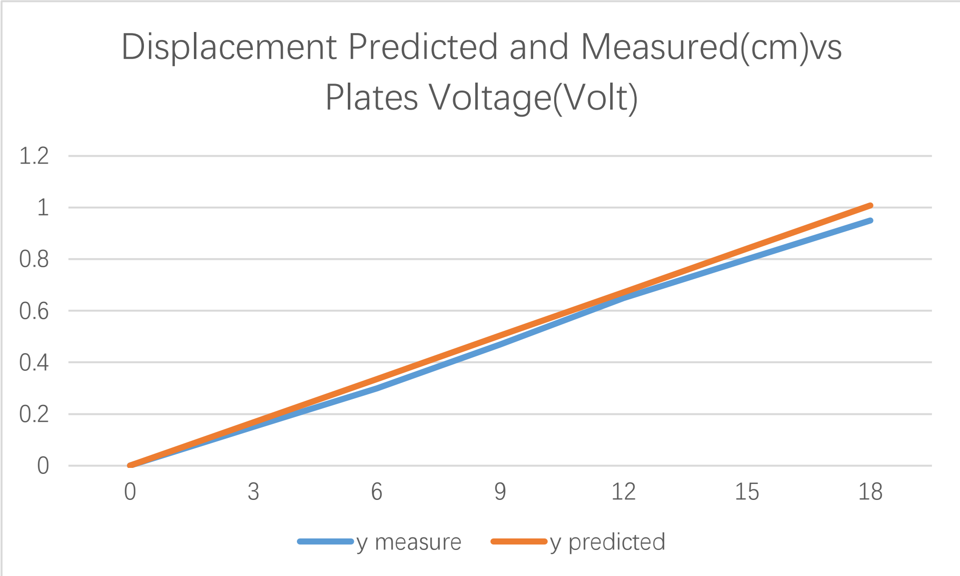



**Figure: the theoretical deflection distance and the deflection distance measured with the 7 different magnitude of deflection electric field. According to the deviation between seven different magnitudes of measured deflection and predicted deflection.The average deviation is 0.023 cm. The uncertainties in all deflection distance measured is ±0.023cm. It is reasonable enough that differences between the theoretical and measured values are almost in the range of random uncertainties.**

## Conclusion:

**The deflection of the electron beam is determined by the magnitude of the deflection electric field while keeping other variables a constant value and the relationship matched the predicted equation. The deflection distance will linear increase with an increase of the voltage across the deflection plates.**