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Lab: Electric Fields

Course: PHYS-42

Section: M1069

Date: 2024-02-09

Significant Numerical Results

Point Source
RMSE = 2.843×10^{-2}

Thin Line of Charge
RMSE = 2.72×10^{-3}

Thin Ring of Charge
RMSE = 9.275×10^{-2}

Measured x_{max} from plot = 10.61 cm

Theorectical x_{max} = 10.61 cm

Difference: 0%

Second derivative at x_{max}: -2.026×10^{-5}

Conclusion

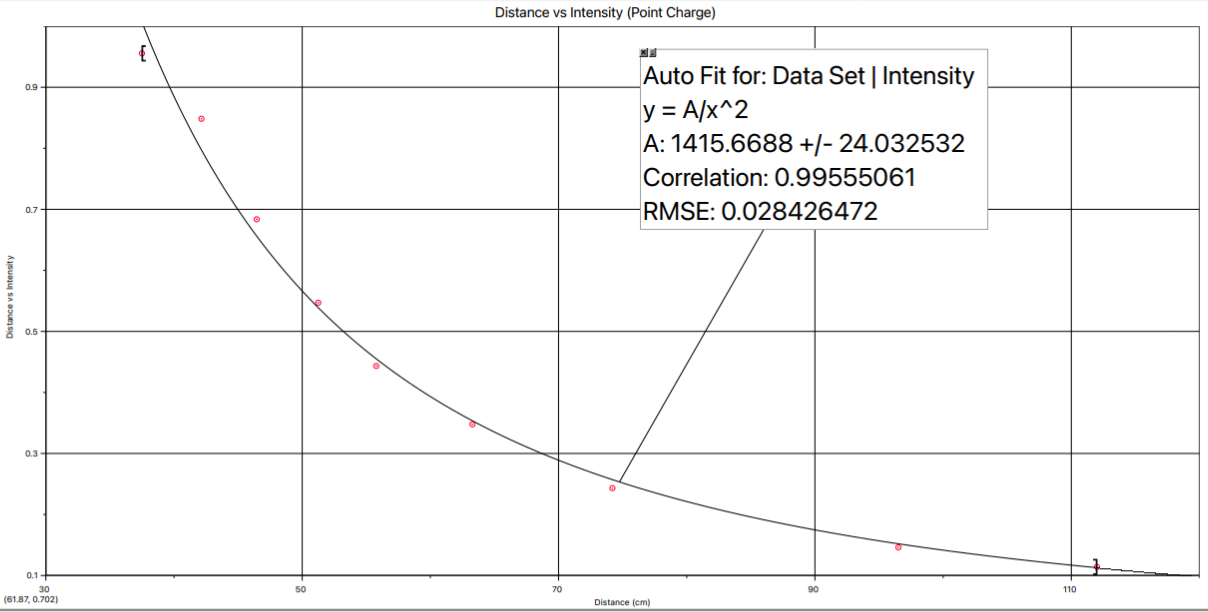
Our group was given three different equations for electric fields in three theoretical charge distributions. In our experiment, we successfully validated the accuracy of these equations by gathering data and plotting them.

All three situations resulted in plots with small root-mean-square errors relative to the values of intensity we measured. As a result, we concluded that the equations could accurately determine the electric field for their respective situations.

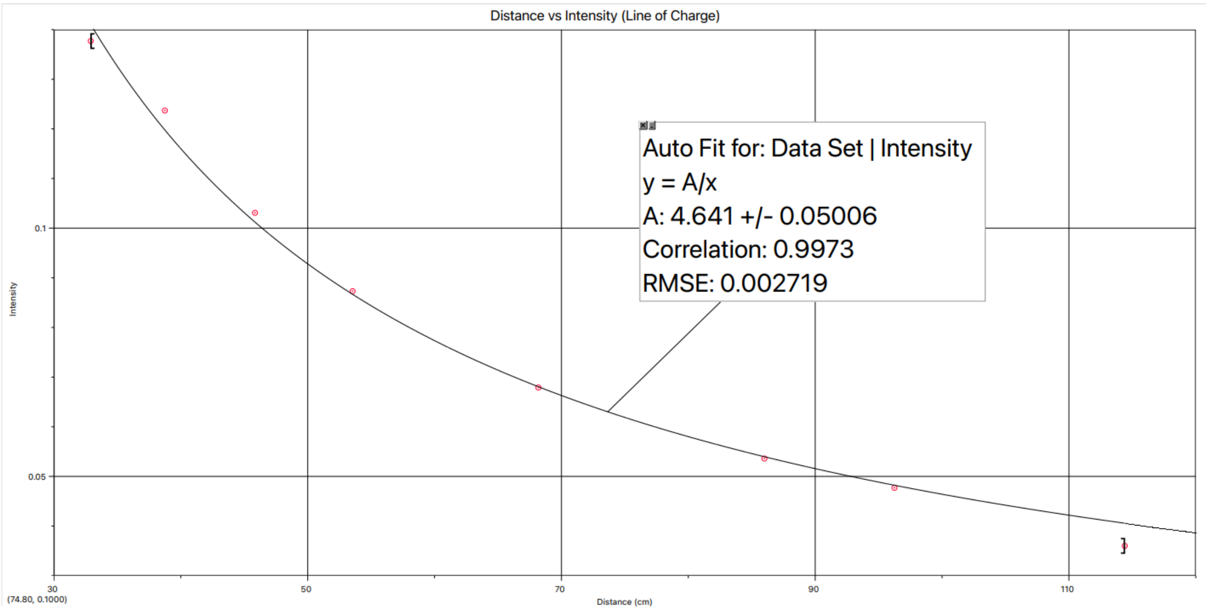
Parts of our procedure could have introduced some error. For example, we relied on our photometer to gather intensity data. It's possible it could have malfunctioned and gave us inaccurate intensity measurements. Moreover, other light sources in the room such as cell phones could have introduced unaccounted for intensity. Inaccurate intensity readings could change our plots and result in larger or smaller root-mean-square errors.

Plots

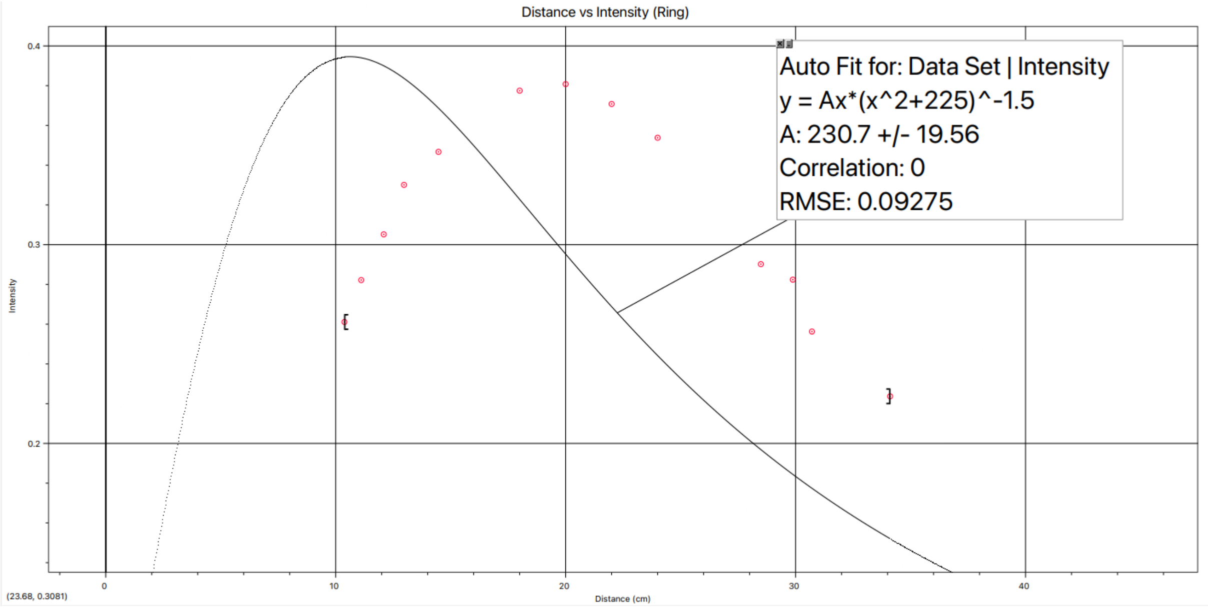
Distance vs. Intensity (Point Source)



Distance vs. Intensity (Thin Line of Charge)



Distance vs. Intensity (Thin Ring of Charge)



Raw Data

Point Source

x (cm)	Intensity (–)
10.00	1.0006
37.50	0.9555
42.14	0.8484
46.45	0.6837
51.25	0.5470
55.78	0.4433
63.28	0.3478
74.20	0.2432
96.51	0.1462
112.00	0.1140

Thin Line of Charge

r (cm)	Intensity (–)
32.90	0.1377
38.74	0.1237
45.85	0.1031
53.54	0.0873
68.18	0.0679
86	0.0536
96.25	0.0477
114.40	0.0360

Thin Ring of Charge

x (cm)	Intensity (–)
10.38	0.2611
11.11	0.2822
12.09	0.3052
12.97	0.3301
14.47	0.3467
18.00	0.3775
20.00	0.3808
22.00	0.3708
24.00	0.3538
28.49	0.2902
29.88	0.2824
30.71	0.2563
34.11	0.2237

Radius of ring = 15.00 cm

Calculations

Measured x_{max} :

$$y = \frac{230.7x}{(x^2 + 225)^{\frac{3}{2}}}$$

$$\frac{dy}{dx} = -\frac{4614x^2 - 519100}{10(x^2 + 225)^{\frac{5}{2}}}$$

$$0 = -\frac{4614x^2 - 519100}{10(x^2 + 225)^{\frac{5}{2}}}$$

x shouldn't be negative as our position values and radius are all positive

$$\boxed{x_{\text{max}} = 10.61 \text{ cm}}$$

Theoretical x_{max} :

Thin ring of charge: $E = \dfrac{kqx}{(x^2 + R^2)^{\frac{3}{2}}}$

$$\frac{dE}{dx} = -\frac{2x^2 - R^2}{(x^2 + R^2)^{\frac{5}{2}}}$$

$$0 = -\frac{2x^2 - R^2}{(x^2 + R^2)^{\frac{5}{2}}}$$

$$x_{\text{max}} = \frac{R}{\sqrt{2}}$$

$$x_{\text{max}} = \frac{15.00 \text{ cm}}{\sqrt{2}}$$

$$\boxed{x_{\text{max}} = 10.61 \text{ cm}}$$

Percent Error x_{max}

$$\text{Percent Error} = \frac{10.61 - 10.61}{10.61} = \boxed{0\%}$$

Second Derivative

$$\frac{d}{dx}\left[-\frac{2x^2 - R^2}{(x^2+R^2)^{\frac{5}{2}}}\right] = \frac{6x^3 - 9R^2x}{(x^2+R^2)^{\frac{7}{2}}}$$

$$\frac{6(10.61)^3 - 9(15.00)^2(10.61)}{\left((10.61)^2 + (15.00)^2\right)^{\frac{7}{2}}}$$

$$= \boxed{-2.026 \times 10^{-5}}$$

Negative number, agrees with calculus maxima having a negative second derivative