Score

Physical Experiment Ⅱ

Physics Lab Report 11

Experiment Title:	The Millikan Oil Drop Experiment
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Score

Abstract (About 100 words, 10 points)

The purpose of this experiment is to calculate the elementary charge by observing and measuring the electric charges carried by an oil droplet. Firstly, we are supposed to choose some proper oil droplets with appropriate speed. And then we use the electron microscope to observe the proper oil droplet and record the balance voltages and fall times when the droplet dropping from one level line to the other line over the screen for three times for each oil droplet. After this we use some physical equations to help us to get and analysis the elementary charge. During this experiment, it is also benefit for us to operate these sets of apparatus skillfully.

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Calculations and Results (Calculations, data tables and figures; 15 points)

Calculations

(1) Compute the mean values of the balance voltage and the fall time.

For the first oil droplet

$$\overline{V_1} = \frac{V_{11} + V_{12} + V_{13}}{3} = \frac{46V + 46V + 46V}{3} = 46V$$

$$\overline{t_1} = \frac{t_{11} + t_{12} + t_{13}}{3} = \frac{16.4s + 15.4s + 14.8s}{3} = 15.53s$$

Compute the averaged values of the ten oil droplets and put them in Data Table 4-1.

(2) Use the following equation to calculate the charges carried by an oil droplet. Show the sample calculation for the first droplet and list all the charges in Table 4-2.

$$\bar{q} = ne = \frac{1.43\times10^{-14}}{[\bar{t}(1 + 0.02\sqrt{\bar{t}})]^{\frac{3}{2}}} \cdot \frac{1}{\bar{V}}$$

The sample calculation for the first droplet is shown as following:

$$\bar{q} = ne = \frac{1.43\times10^{-14}}{[\bar{t}(1+0.02\sqrt{\bar{t}})]^{\frac{3}{2}}}\cdot\frac{1}{\bar{V}} = \frac{1.43\times10^{-14}}{[15.53(1+0.02\sqrt{15.53})]^{\frac{3}{2}}}\cdot\frac{1}{46} = 45.36\times10^{-19}\text{C}$$

Table. 4-2 the charges and the number of excess electrons on measured droplets

Oil droplets	Charges $\bar{q}$ (C)	the number of excess electrons, *n*	Elementary charge e(C)
1	45.36×10^{-19}	28	1.62×10^{-19}
2	22.36×10^{-19}	14	1.59×10^{-19}
3	18.76×10^{-19}	12	1.56×10^{-19}
4	25.55×10^{-19}	16	1.59×10^{-19}
5	30.58×10^{-19}	19	1.60×10^{-19}
		Averaged	1.592×10^{-19}

(3) Compute the number of excess electrons for every droplet. Suppose that the elementary charge e=1.602×10^{-19} C and the number of excess electrons is

$$n = [\frac{q}{e}]$$

("[ ]" means rounding the quotient to an integer)

Show the sample calculation for the first oil droplet and put all the results in Table 4-2.

The sample calculation for the first droplet is shown as following:

$$n = \left[\frac{q}{e}\right] = \left[\frac{45.36\times10^{-19}}{1.602\times10^{-19}}\right] = 28$$

(4) Compute the elementary charge.

$$e = \frac{\bar{q}}{n}$$

Show the sample calculation for the first oil droplet and put all the results in Table 4-2.

The sample calculation for the first droplet is shown as following:

$$\mathbf{e = \frac{\overline{q}}{n} = \frac{45.36\times10^{-19}}{28} = 1.62\times10^{-19}C}$$

(5) Compute the averaged elementary charge. Put the final result in Table 4-2.

$$\mathbf{\bar{e} = \sum_{i=1}^{10} e_i = 1.592\times10^{-19}C}$$

(6) Compute the relative error of the elementary charge.

$\mathbf{E = \frac{\bar{e}-e}{e}\times100\% = \frac{1.592\times10^{-19}C-1.602\times10^{-19}\,C}{1.602\times10^{-19}C}\times100\% = 0.624\%}$ (e=1.602×10^{-19} C)

DATA TABLE 4-1 (*purpose*: to measure the electric charges carried by an oil droplet)

Oil droplets	Balance voltage V(v)		Fall time t(s)	
	Measurement	Averaged	Measurement	Averaged
1	46V	46V	16.4s	15.53s
	46V		15.4s	
	46V		14.8s	
2	203V	203V	9.4s	9.40s
	203V		9.5s	
	203V		9.3s	
3	119V	119V	15.0s	14.87s
	119V		14.8s	
	119V		14.8s	
4	53V	53V	20.6s	6.50s
	53V		20.4s	
	53V		20.5s	
5	36V	36V	23.6s	23.40s
	36V		23.4s	
	36V		23.2s	

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Conclusions (About 100 words, 5 points)

From this experiment, we can get the result that the elementary charge is about $1.592\times10^{-19}C$ by measuring and calculating the electric charges carried by an oil droplet. Although the result we got is not exactly equal to the theoretical value (1.602×10^{-19}C), the relative error of it is small. One of the most important is choosing the proper oil droplet with appropriate speed which is helpful to reduce the error as possible. Besides, we also review some knowledges about electron, electric field and Stokes' law which help us digest more about the friction when object moving in medium.

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Answers to Questions (10 points)

(1) According to these two equations:

$$F_G = mg = \frac{4}{3}\pi r^3 \rho$$

$$F_v = 6\pi r \eta v$$

It is obvious that the bigger mass of the oil and the smaller charge can make the droplet drop more quickly, since the power of the r is 3 in the first equation while that is 1 in the second equation. So, it need larger velocity to gain more friction to balance the force pointing up.

(2) No, these droplets are not good for measurement. The light oil droplets which drop slowly in the media is easily affected by the airflow. That is to say, the larger error would be caused with longer falling time.

(3) The accurate value of elementary charge is important for us to obtain the number of charges that an object have after measuring the amount of charges.

Appendix

(Scanned data sheets)

3.11.5 Experimental Data

Data Table 3.11-1 ***Purpose***: **To measure the electric charges carried by an oil droplet**

Oil droplets	Balance voltage *V*/V		Fall time *t*/s	
	Measurement	Average	Measurement	Average
1	46 V 46 V 46 V	46 V	16.4 15.4 14.8	15.535
2	203 V 203 V 203 V	203 V	9.4 9.5 9.3	9.405
3	119 V 119 V 119 V	119 V	15.0 14.8 14.8	14.875
4	53 V 53 V 53 V	53 V	20.6 20.4 20.5	20.505
5	36 V 36 V 36 V	36 V	23.6 23.4 23.2	23.40
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