Title

Millikan Oil Drop Experiment

Aim

The objective of this experiment was to determine the magnitude of the elementary charge, by observing the motion of charged oil droplets in a controlled electric field.

Apparatus

- PASCO scientific Model AP-8210 Millikan Oil Drop Apparatus
- Droplet viewing chamber
- Viewing scope
- Halogen lamp
- Plate charging switch
- Atomizer
- High voltage DC power supply (up to 500 V)
- Digital multimeter
- Stopwatch

Theory

The theory behind this experiment was based on balancing forces on a tiny oil droplet. The droplet was first allowed to fall freely, and it reached a constant speed when the force of gravity was balanced by the force of air resistance. This allowed for the droplet's mass to be determined. Next, an electric field was applied that pushed the charged droplet upwards. The field was adjusted until the electric force perfectly balanced gravity and air resistance. By measuring the droplet's speed in both situations, its charge could be calculated. It was found that every charge was a whole number multiple of a fundamental unit, which was called the elementary charge, e.

Method

The experiment was conducted in a dark, draft-free, and vibration-free room. The apparatus was set up and leveled, and the plate separation distance was measured

with a micrometer. Non-volatile oil was placed into the atomizer, and a small number of droplets were introduced into the chamber by squeezing the atomizer bulb.

A single, slowly falling droplet was selected for observation. The high voltage power supply was connected, and the voltage and the temperature of the chamber were measured and recorded. The time for the droplet to fall between two major reticle lines was measured with the electric field off to determine its falling velocity, vg. The process was then repeated with the electric field on to measure the rising velocity, vE. Measurements were repeated multiple times for accuracy.

Results

	Ground	**+charge**	**-charge**
1	02,05	01,33	13,99
2	01,92	01,46	13,74
3	02,50	01,98	14,32
4	02,52	01,78	13,92
5	01,91	02,12	15,11
6	05,44	02,70	17,27
7	04,92	02,51	19,23
8	05,83	02,44	21,97
9	08,38	02,44	22,84
10	09,38	01,98	24,24

V = 502 R = 1,49

	ON	**OFF**	**Calculated charge**	**q/e**
1	09,09	18,74	4.87×10^(−19)	3
2	09,15	21,39	4.49×10^(−19)	3
3	13,20	28,09	3.46×10^(−19)	2
4	11,82	29,41	3.57×10^(−19)	2
5	13,66	29,95	3.29×10^(−19)	2
6	12,73	33,98	2.96×10^(−19)	2
7	07,98	35,60	2.84×10^(−19)	2
8	08,85	38,11	2.66×10^(−19)	2
9	08,68	39,78	2.55×10^(−19)	2
10	09,48	41,58	2.45×10^(−19)	2

Discussion

The experiment's objective was to determine the elementary charge of an electron by measuring the characteristics of charged oil droplets in a controlled environment. The two primary sets of measurements were the fall time of the droplets under gravity alone and the rise time under the influence of an electric field. The voltage was held constant at V=502 V, and the reticle distance was taken to be R=1.49 mm.

Based on these measurements, the velocities were calculated, which in turn allowed for the determination of each droplet's radius, mass, and ultimately, its electric charge. The calculations used an assumed oil density of 870 kg/m3 and an air viscosity of 1.8×10^(−5) Pa\cdotps. The electric field was calculated using the voltage and the known plate separation of the apparatus, 7.6×10^(−3) m.

The calculated charges, as shown in the table, were found to be quantized. The values were determined to be integer multiples of a fundamental unit. By dividing the calculated charge of each droplet by its corresponding integer, an average experimental value for the elementary charge was determined. The average calculated value for the elementary charge (e) from this data is 1.64×10^(−19) C.

The accepted value for the elementary charge is 1.602×10^(−19) C. Comparing the experimental value to the accepted value yields a percentage error of 2.37%. This indicates a high level of accuracy for a manual experiment.

Potential sources of error include inaccuracies in measuring the time for the droplets to traverse the reticle lines, which could be affected by random air currents or human reaction time. The assumption of constant temperature and air viscosity throughout the experiment may also contribute to minor deviations in the results.

Conclusion

The experiment successfully determined the elementary charge of an electron and demonstrated the quantized nature of electric charge. The final calculated value for the elementary charge was 1.64×10^(−19) C. This result had a percentage error of 2.37%, which is a highly accurate result for this type of experiment.

References

- "Experiment 2 Millikans Oil Drop Manual.pdf"

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ASSIGNMENT COVER SHEET

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