Milikan Oil Drop Experiment

Jason Morgan
Department of Physics, Old Dominion University, Norfolk VA 23529
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This experiment determines the charge of an electron by comparing the gravational force on the oil drop to the electromagnetic force on the oil drop. This is accomplished by place an electric charge on the drops while suspended in air and switching an electric field on and off.

1. INTRODUCTION

The charge of the electron was found in this experiment be measuring the total charge emparted to an oil drop and calculating a common factory. This was accomplished using the Milikan oil drop apparatus. This works by atomizing mineral oil and suspending is in a chamber where it is exposed to alpha particles which impart and electric charge to the drops. The device also has a capacitor that produces an electric field. This field is used to cause the drops to rise in the gravational field. The rise and fall times of the drops can then be measured and the from that the forces acting on the drop can be deduced. This allows for the calculation of the charge of the electron.

2. EXPERIMENTAL SETUP AND PROCEDURES

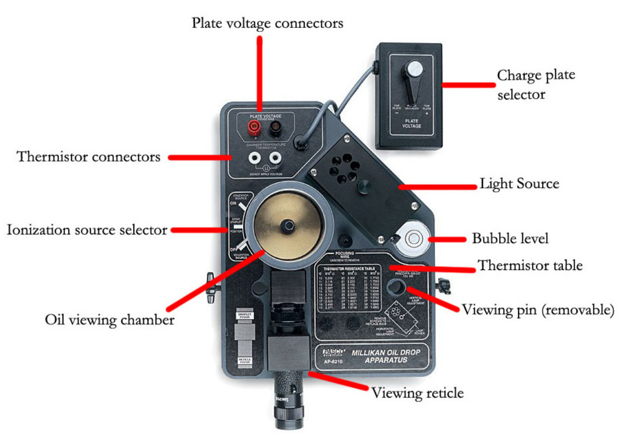

FIG. 1: Oil Drop Apparatus Components

Procedures

$$q = \frac{4}{3}\pi\rho g\left[\sqrt{\left(\frac{b}{2p}\right)^2 + \frac{9\,\eta\, v_f}{2g\rho}} - \frac{b}{2p}\right]^3 \frac{v_f + v_r}{E\, v_f}, \quad (1)$$

where:

q - total charge ($coulombs$)
d - separation on plates (m)
ρ - density of oil (kg/m^3)
g - acceleration of gravity (m/s^2)
η - viscosity of air (Ns/m^2)
b - barometric pressure ($Pa - m$)
v_f - velocity of falling drop (m/s)
v_r - velocity of rising drop (m/s)
E - voltage/d ,

To time the rise and fall times of the drops, a custom timer application was used. This application was developed by a previous team to allow the times to be recorded more efficently than using a stopwatch. To begin the experiment the equipment was cleaned, the plate seperation was measured and the foucus of the eye piece was calibrated. Then, with the ionization source turned off, a small mist of oil was introduced to the chamber. Then the ionazation source was turned on for a few seconds to impart an electric charge to the oil drops. The drops were watched while turning the electric fiele on and off until a drop was found that both had a charge and was easily tracked.

Once this drop was itentified the electric field was turned off and the timer was started when the drop crossed one of the major reticle lines. When the droped passed the next major reticle line, the times was restarted and the electric field was turned on. The application used recorded the times when the restarts occured.

This procedure was repeated while exposing the oil drops for varing periods of time to the ionizarion source.

3. RESULTS AND DISCUSSION

It was found to be quite difficult to find an oil drop that could be tracked for an extended period of time. Many attempts were made to get a good run of data and eventually there were three data sets that were acceptable. The averages for these trials is in Table I. The data is inserted into equation (**??**) to produce the value for the charge which is listed in Table II.

TABLE I:

Trial	Average $v_r (m/s)$	Average $v_f (m/s)$
1	2.51×10^{-5}	3.51×10^{-5}
2	9.49×10^{-5}	2.91×10^{-5}
3	1.19×10^{-4}	6.45×10^{-5}

This charge is divided by the smallest charge found and this charge is assumed to be the charge of one electron. The data in

TABLE II:

Total Charge (coulombs)	No. e Calc	No. e Actual
$1.31 \times 10^{-19} (\pm 4{\times}10^{-21})$	1 (1.00)	1 (0.82)
$3.02 \times 10^{-19} (\pm 2{\times}10^{-21})$	2 (2.30)	2 (1.88)
$6.72 \times 10^{-19} (\pm 1{\times}10^{-21})$	5 (5.12)	4 (4.19)

The data shows fractional numbers of electrons which is not possible and this number is rounded to the nearest integer. The data in the last column is the number of electrons calculated by using the actual value for the charge of the electron. This is primarily due to the error in measuring the rise and fall times as well as not using the actuall barimetric pressue due to the lack of a barameter. The error could be decreased by being able to make more rise and fall measurements for each drop.

Using the smallest value obtained for the charge as the charge of one electron gives $1.31 \times 10^{-19} \pm 4 \times 10^{-21}$ coulombs. This varies from the accepted value of 1.60×10^{-19} coulombs by 18%.

4. CONCLUSION

This experiment was difficult to perform because of the difficulty in performing trials that lasted long enough to perform more that 10 rise and fall pairs. There was also significant turn around time between trials as a it took some time to get a decent mist of oil drops and find one to track.

[1] Sunny Bishop, *MILLIKAN OIL DROP APPARATUS*, (10101 Foothills Blvd. Roseville, CA).