Millikan's Experiment Revisited

Description of the Millikan Experiment using the Mass-Charge Force

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Abstract

It may be that Millikan's classic oil drop experiment is not driven by the force of gravity—which acts in opposition to the electric force—but that it is rather the mass-charge force that pulls the charged droplets of oil down to earth. Accordingly, the force of gravity would have only an extremely small effect in opposition to the electric force, and the mass-charge force would act as the major opposing force to the electric force. Thereby the mass charge forceis the force between the earth's mass and the charge of the oil droplets. This force is believed to act in opposition to the electric force and as an opposing force to the Stokes frictional force. We show that this novel interpretation of the Millikan experiment leads to identical results and an identical value for the elementary charge e as the original interpretation conducted by Millikan.

Introduction

Millikan's experiment is an experiment that was carried out by the American physicists Robert Andrews Millikan and Harvey Fletcher in 1910. The experiment was conducted to determine the magnitude of the elementary charge more accurately than it had hitherto been possible [1,2] . For this experiment and the ensuring measurement, Robert Millikan received the 1923 Nobel Prize in Physics.

Following the suggestion of Robert Millikan, his advisor, PhD student Harvey Fletcher improved upon several experiments previously conducted by Harold Albert Wilson, Joseph John Thomson and other researchers. Fletcher conducted these experiments, which he significantly improved. Thereby, his most important improvements consisted of replacing the previously used substances (i.e., water and/or alcohol) with slow-to-evaporate liquids such as oil and mercury [3]. In order to determine the magnitude of the elementary charge e, the falling rate of electrically charged oil droplets was measured in the presence of an electric field and compared with the case without an electric field. The determined value of the elementary charge was [1,3]:

$e = 1.592\ 10^{-19}\ C$

Harvey Fletcher made a deal with Robert Millikan, which was revealed posthumously in the journal *Physics Today* after Millikan's death in 1982 [4]. As a result of this deal, Harvey Fletcher received his PhD and Millikan received the Nobel Prize without sharing it with Harvey Fetcher.

Below, corresponding calculations to the well-known calculations conducted by Millikan are performed using the novel mass-charge force.

Equations

mass charge force equals Stokes friction force – free fall

$$F_{mq} = F_R = F_{Stoke} \quad (1)$$

$$bgq = 6\pi r\eta v \quad (2)$$

$$q = \frac{1}{bg}6\pi r\eta v \quad (3)$$

$$r = \sqrt{\frac{9\eta v}{2\rho g}} \quad (4)$$

$$q = \frac{1}{bg}6\pi\sqrt{\frac{9\eta v}{2\rho g}}\eta v \quad (5)$$

$$q = \frac{1}{bg}6\pi\sqrt{\frac{9}{2}\frac{\sqrt{g}}{g}\frac{\sqrt{\rho}}{\rho}}\sqrt{\eta^3}\sqrt{v^3} \quad (6)$$

floating drop

$$F_{mq} = F_{el} \quad (7)$$

$$Eq = bgq \quad (8)$$

$$E = bg \quad (9)$$

$$\frac{d}{U} = \frac{1}{bg} \quad (10)$$

$$q = \frac{d}{U} 6\pi \sqrt{\frac{9}{2}\frac{\sqrt{g}}{g}\frac{\sqrt{\rho}}{\rho}} \sqrt{\eta^3}\sqrt{\upsilon^3} \quad (11)$$

Uniform motion of the droplets

In this case, the mass-charge force (and not the force of gravity) acts in opposition to the Stokes frictional force in the case of uniform motion of the oil droplets (equations 1-6).

Floating of the droplets

In this case, the mass-charge force (and not the force of gravity) acts in opposition to the electrostatic force, which keeps the droplets floating (equations 7-11).

Double substitution

The substitution of the gravitational force by the mass-charge force therefore occurs in the same way in two different places. Here, the influences of these two substitutions (equations 1-6 and equations 7-11) compensate each other (cancel out) at the end of the calculations. We show here that exactly the same equations and therefore the same results for the determination of the elementary charge follow, which also result in the well-known outcome using the gravitational force.

Here, we assume that the charge of the oil droplets is coupled to the gravitational field of the earth. This force should be described by $g \times q$ and should be significantly greater than the well-known gravitational force of the oil droplets, which is described by $g \times m$.

Since identical results follow as well as in the classical interpretation of the Millikan experiment, it might well be that in truth that the gravitational force does not have to be considered here as an counteracting force of electricity; instead, the mass-charge force is responsible for this phenomenon.

To distinguish which interpretation is correct, more accurate measurements of the droplets' characteristics in the laboratory would be needed.
In Millikan's time, it was not possible, for technical reasons, to precisely determine a large number of these parameters. These parameters that needed to be measured more accurately included the acceleration of the oil droplets before they exhibited uniform movement, the size (volume) and mass of the droplets.

Millikan's original experiment was a mixture of measured parameters (e.g., the uniform droplet velocity and the field voltage when the droplet was floating) and calculated parameters.

None of the parameters—droplet radius, droplet acceleration, and/or droplet mass—were measured experimentally in the original oil drop experiment; these parameters were derived and calculated using mathematics.
If it is technically possible nowadays to measure these parameters directly in experiments by means of modern techniques and without relying on mathematics, then it might be possible to conclude which method is the correct one to use for a given experiment.

When using the mass-charge force, a significantly higher acceleration of the oil droplets results than from using the gravitational force. The force that is acting toward the earth in this experiment would just be noticeably larger than expected given only the force of gravity. When the mass-charge force acts, much-smaller droplets would form with smaller radii and lower masses. Additionally, these droplets would still be able to experience significant accelerations. Even a small droplet should be able to make visible a significantly stronger force (the mass charge force) which is acting in this experiment. Furthermore, droplets with the same radius and of the same mass should experience different accelerations if they differ in charge. Therefore, there should be a broad range of accelerations; some droplets will exhibit very, very small accelerations (i.e., those with no electric charge).

According to the classical interpretation, all of the oil droplets should follow the same acceleration and should in principle exhibit the same kinematics. However, according to novel interpretation, the oil drops should exhibit different accelerations and kinematics as a function of their charge. In general the following law should apply: higher the charge of the droplets, the larger the magnitude of the droplets' acceleration.

References

[1] R. A. Millikan, Physical Review (Series 1) 32, 4, 349 (1911).

[2] Robert Millikan in Britannica Online

[3] R. A. Millikan, Physical Review (Series 2), 2, 2, 109 (1913).

[4] H. Fletcher, Physics Today 35(6), 43 (1982).