

Millikan's Oil Drop Experiment

Encyclopedia Article

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Millikan's Oil Drop Experiment

The discovery of the **electron** in 1897 by English physicist J.J. Thomson led to the beginning of knowledge of **atomic structure**. Thomson showed that charge came in discrete **quanta**, and indirectly measured the charge-to-mass ratio of the electron. However, Thomson's method did not allow him to measure the charge or **mass** ratio directly. Thomson attempted an experiment where he observed the behavior of falling charged water drops. This experiment, however, was inaccurate because the water drops evaporated during the experiment, and Thomson could only estimate how fast they evaporated in order to interpret the results. In 1909, American physicist **Robert Millikan** performed an experiment based on Thomson's earlier attempt, but used charged oil drops instead of charged water drops. This eliminated the evaporation problem and considerably reduced the uncertainty of the experiment. Because of its success (and extreme accuracy, for the time) the experiment is referred to as Millikan's oil drop experiment.

In the experiment, oil drops were sprayed between the plates of a parallel-plate capacitor. A **microscope** installed in the capacitor observed the oil drops. The drops quickly attained terminal **velocity** downwards due to the balance of air resistance and their **weight**. The drops became charged in the spraying process, so an electric field provided by the capacitor was used to make the drops rise rather than fall. The mass of the drops was determined by measuring their radii, because their **density** was known. The major experimental uncertainty lied in determining the drag coefficient for the air resistance **force**. Millikan used a successive approximation procedure to estimate the drag coefficient, but was unable to pinpoint it exactly. By measuring the time necessary for a drop to rise or fall a certain distance, the charge on the drop was determined.

Millikan was able to observe a single drop for several hours. In that time, he observed when a drop gained or lost charges because its velocity changed. He then divided the difference in charge by different integers until he obtained the same result for every change in charge. He performed this experiment on thousands of drops of different composition and conductivity. This allowed him to find the value of the fundamental charge, which he reported as $e = 1.591 \times 10^{-19}$ coulombs. Compared to the present accepted value, $e = 1.602 \times 10^{-19}$ coulombs, Millikan's results are remarkably accurate.