

Going Further into Atomic Structure

Thomson, Rutherford, and Millikan



Where we left off...

- ▶ Dalton's atomic theory
- ▶ 5 postulates

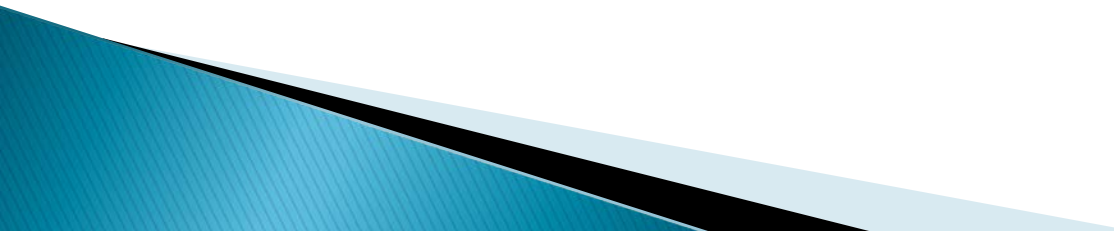
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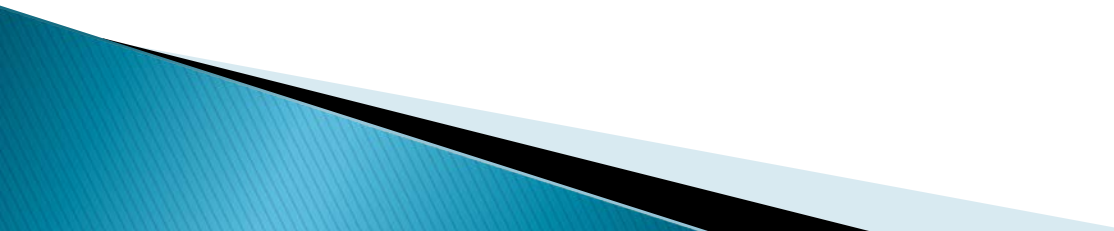
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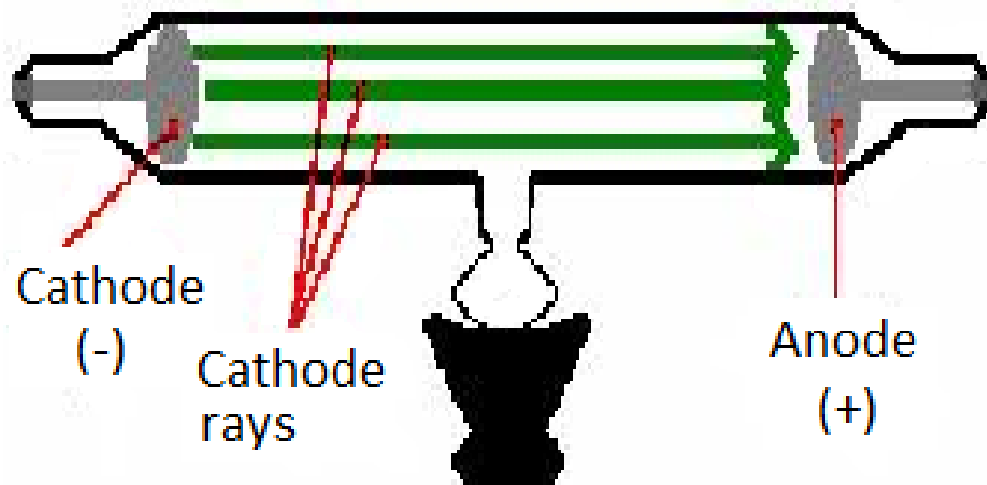
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 - All matter is made up of atoms.
 - An element is made up of atoms that are identical.
 - Atoms of different elements are different from each other.
 - Atoms combine in small whole number ratios to form compounds
 - Atoms of the same elements can combine in different whole number ratios to form different compounds.
 - ex. CO vs. CO₂

Geissler or Crookes Tubes

- ▶ Contain two metal plates in sealed glass tube



Geissler or Crookes Tubes

- ▶ Contain two metal plates in sealed glass tube
- ▶ One metal plate (the “cathode”) emits a glowing “ray” when electrical current is applied

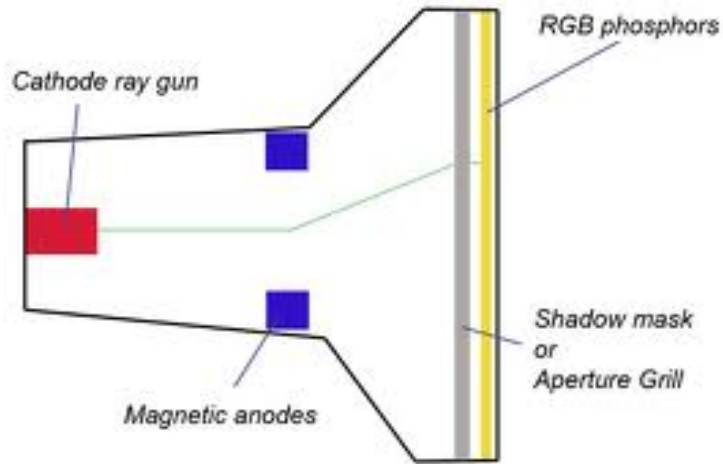


Geissler or Crookes Tubes

- ▶ Also called “cathode ray tubes”



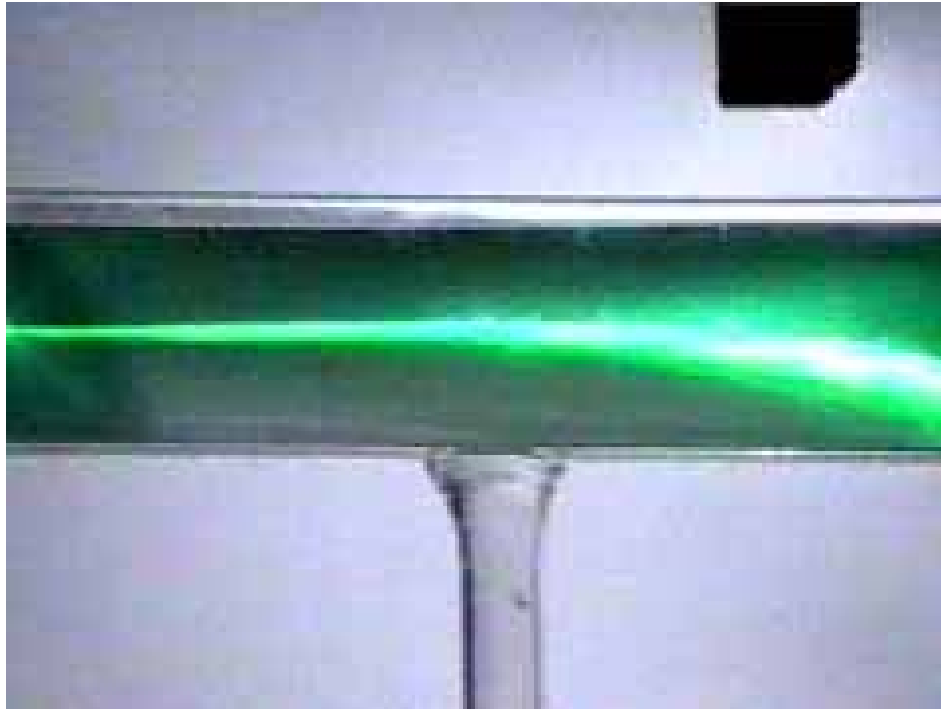
Geissler or Crookes Tubes



- ▶ Also called “cathode ray tubes”
- ▶ Still used in TVs, computer monitors

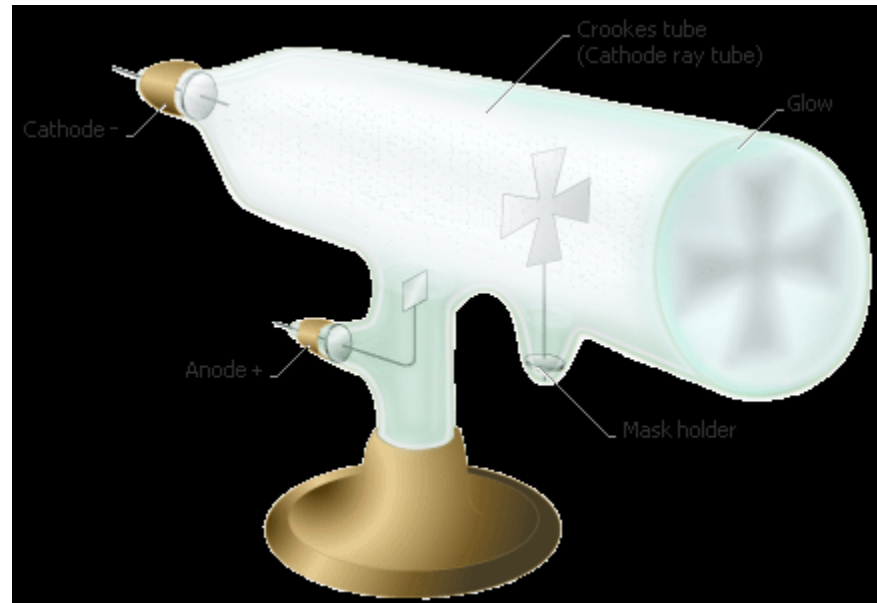


What is the nature of these
“cathode rays”?



Cathode rays cast a shadow

[Video](#)



Cathode rays can turn a paddlewheel

[Video](#)



Cathode Ray Behaviors

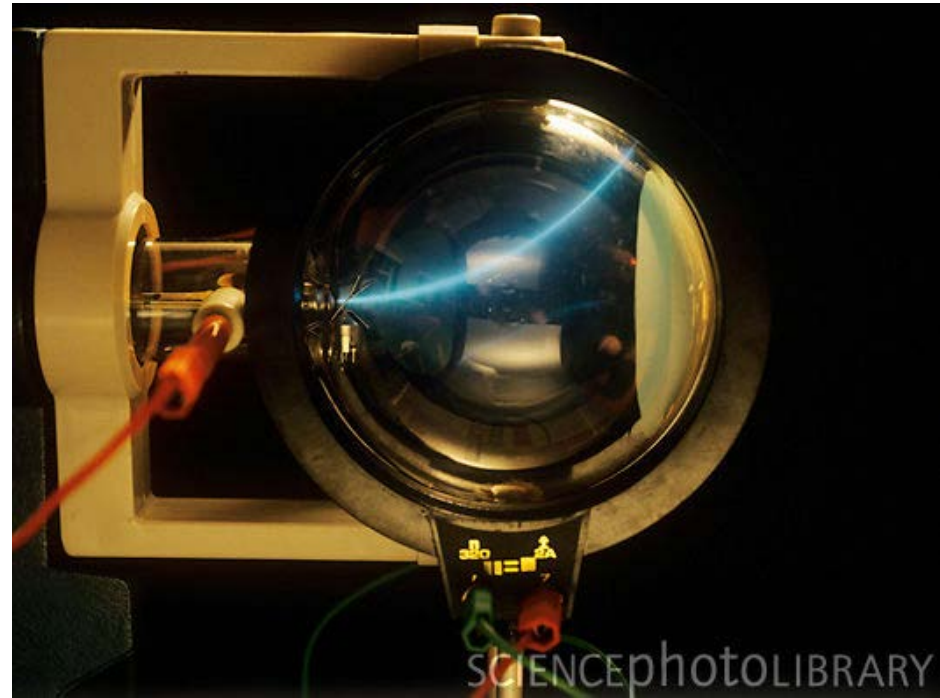
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Cathode Ray Behaviors

- ▶ Cathode rays could be produced by just about any metal tested
- ▶ If directed on a piece of metal, the rays could make the metal glow
- ▶ They showed strange behaviors in presence of magnets...[Video](#)

Cathode rays and magnets

- ▶ Cathode rays are deflected in the presence of a magnetic field



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- ▶ English physicist, 1856–1940



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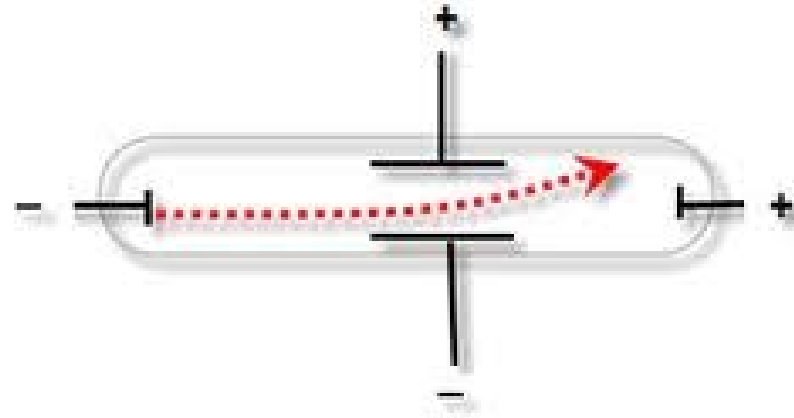
J. J. Thomson



- ▶ English physicist, 1856–1940
- ▶ Nobel Laureate in Physics, 1906
- ▶ Earned scholarship to Cambridge University
- ▶ Trained 7 Nobel Laureates

1897 Experiments

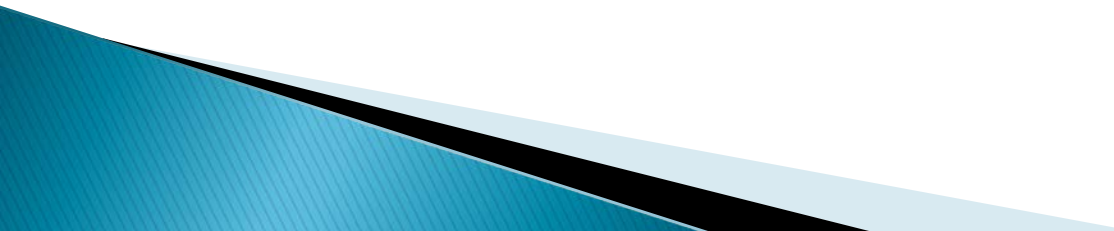
- ▶ Thomson studied the behavior of cathode rays in the presence of an electric field
 - [Animation](#)



1897 Experiments

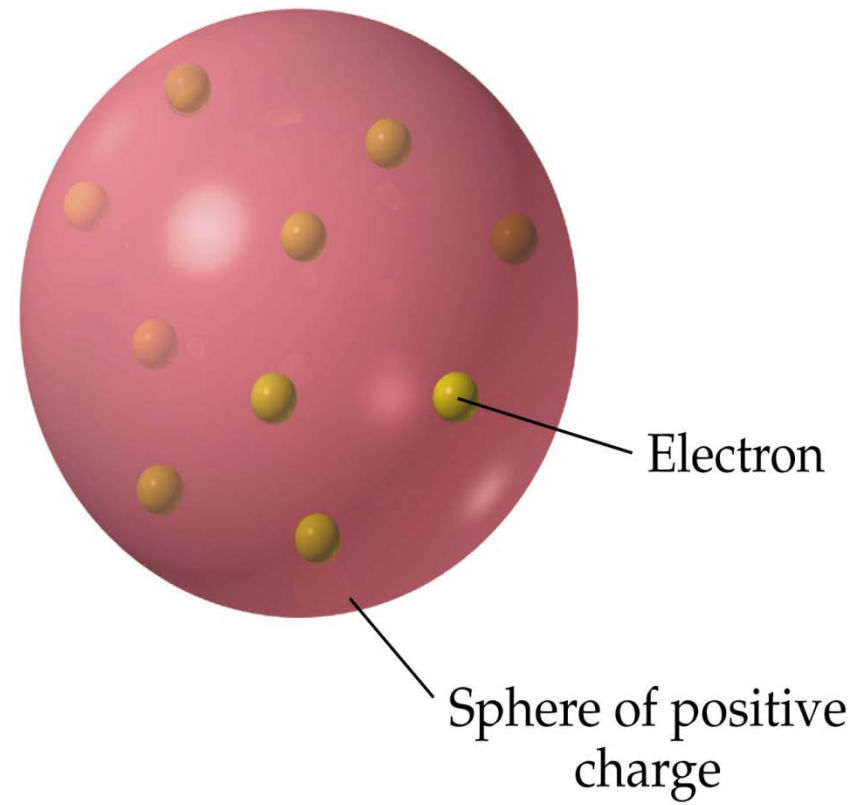
- ▶ Thomson studied the behavior of cathode rays in the presence of an electric field
 - <http://www.aip.org/history/electron/jjappara.htm>
- ▶ Data showed that cathode rays are negatively charged

1897 Experiments

- ▶ Data showed that cathode rays have a negative charge
 - ▶ Thomson measured the mass to charge ratio of cathode rays
- 

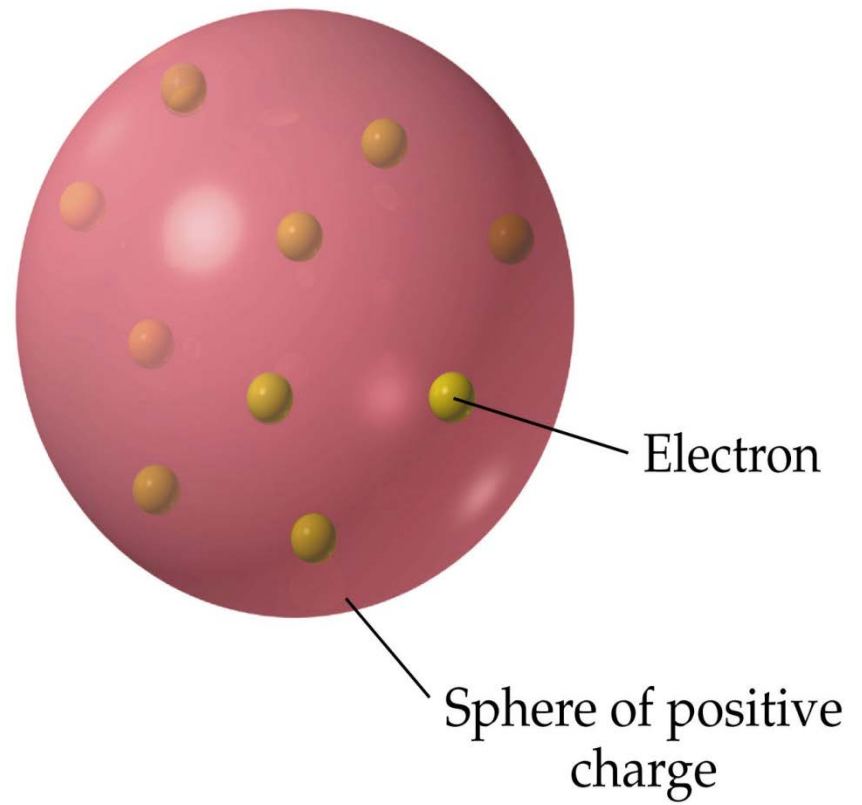
Thomson's model of the atom

- ▶ Atoms known to be electrically neutral, so there must be positive charge in with the electrons



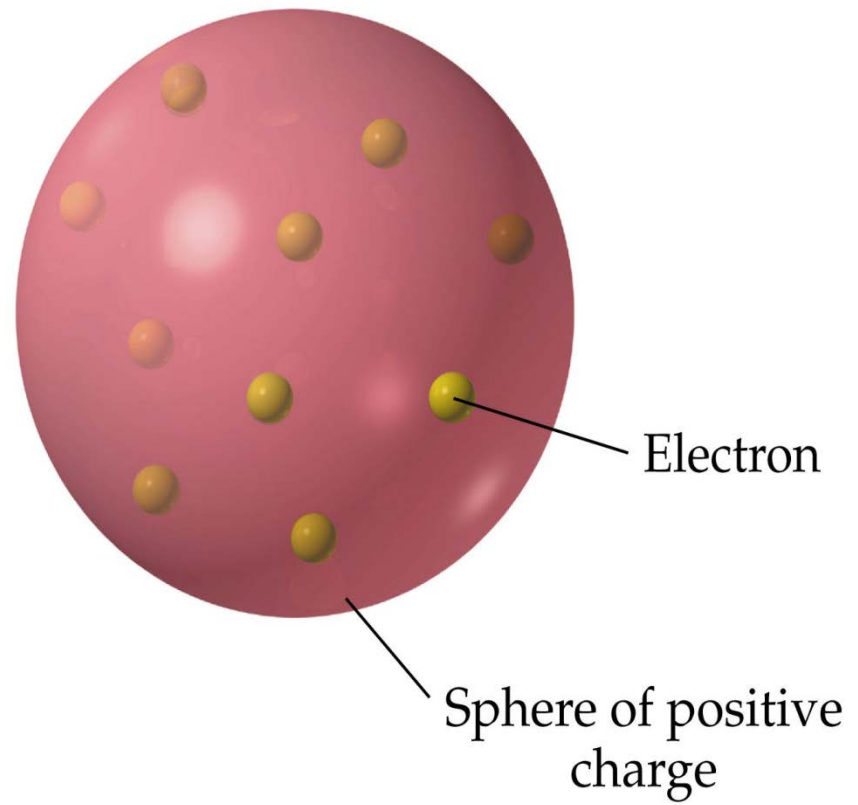
Thomson's model of the atom

- ▶ Proposed that electrons were embedded in gel-like positive charge

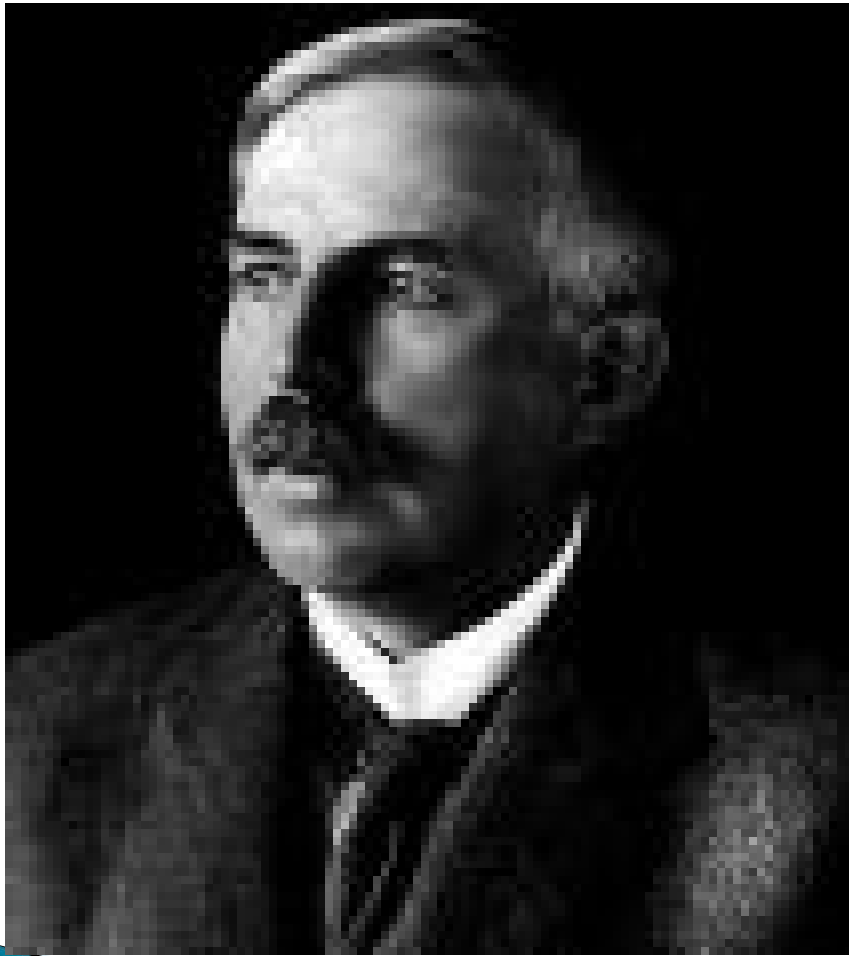


Thomson's model of the atom

- ▶ Proposed that electrons were embedded in gel-like positive charge
- ▶ Called the “plum pudding model”

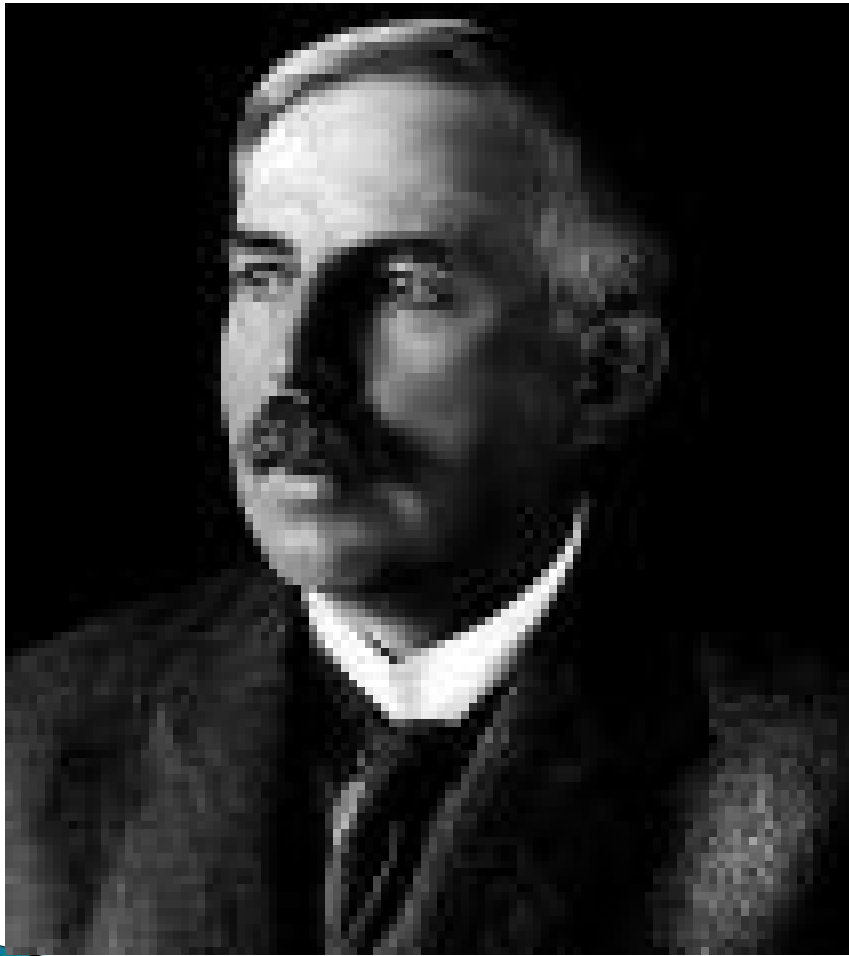


Ernest Rutherford



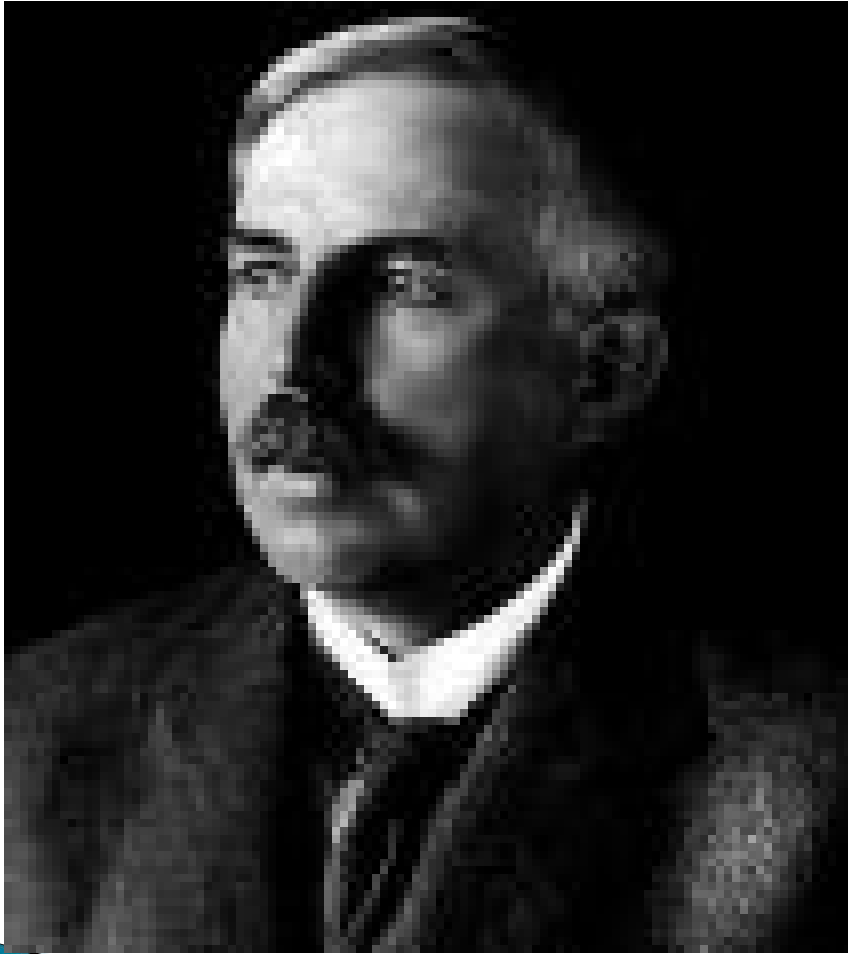
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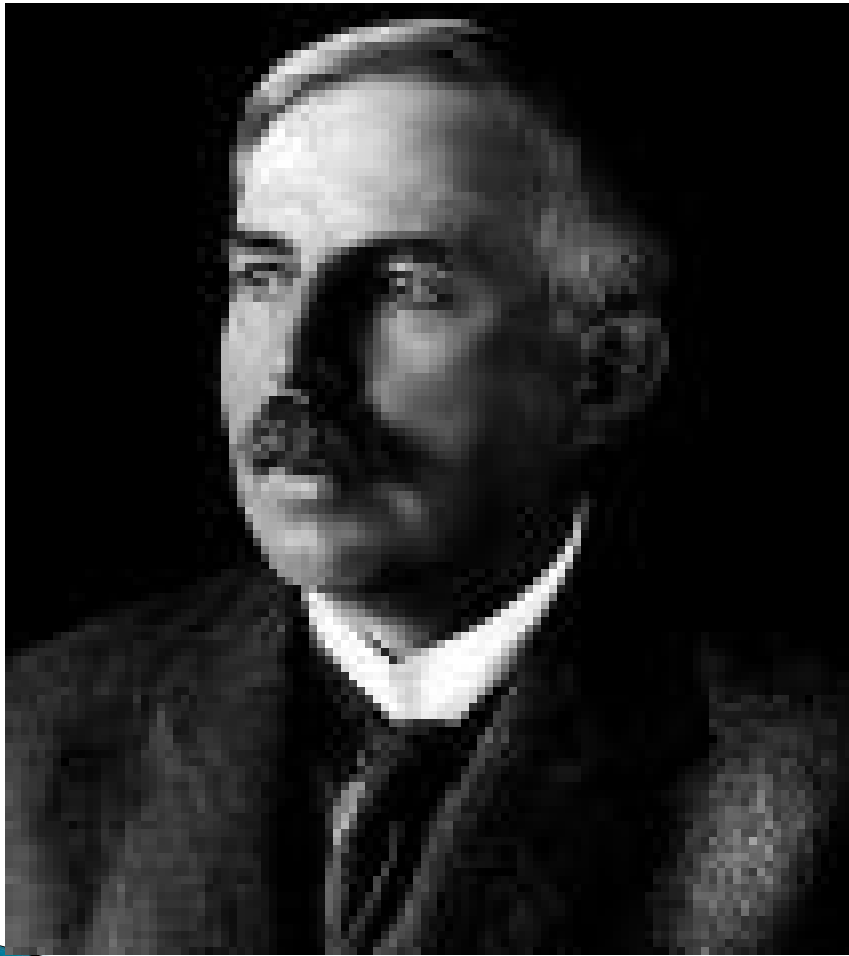
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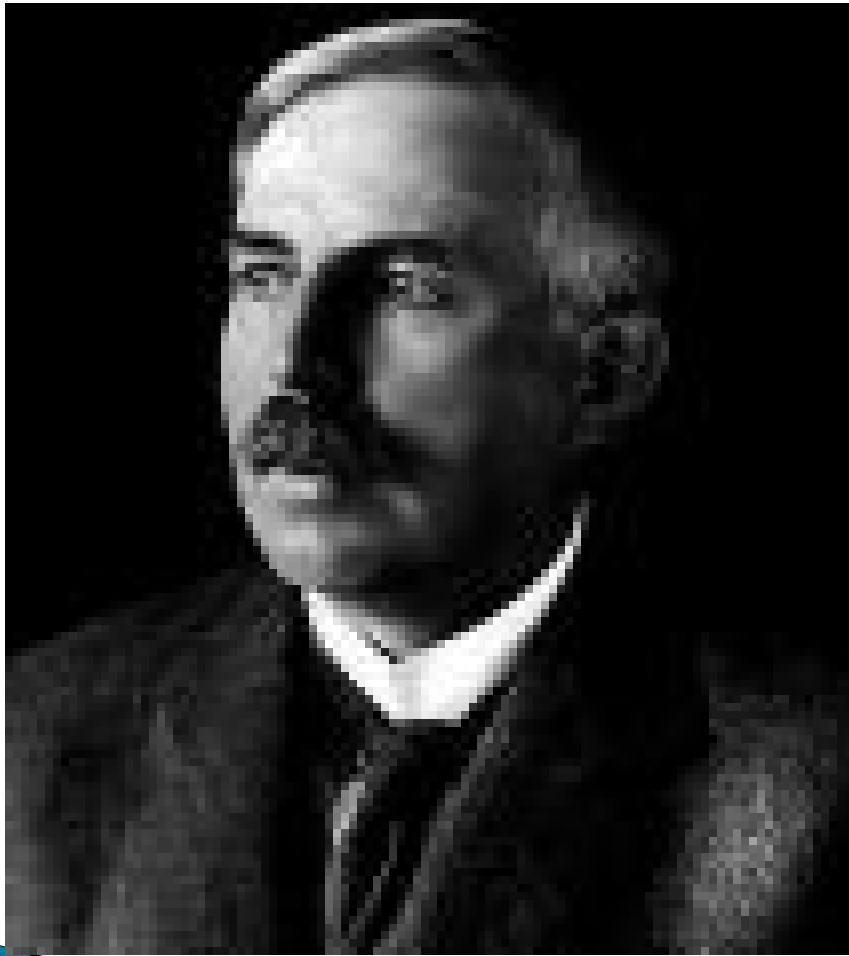
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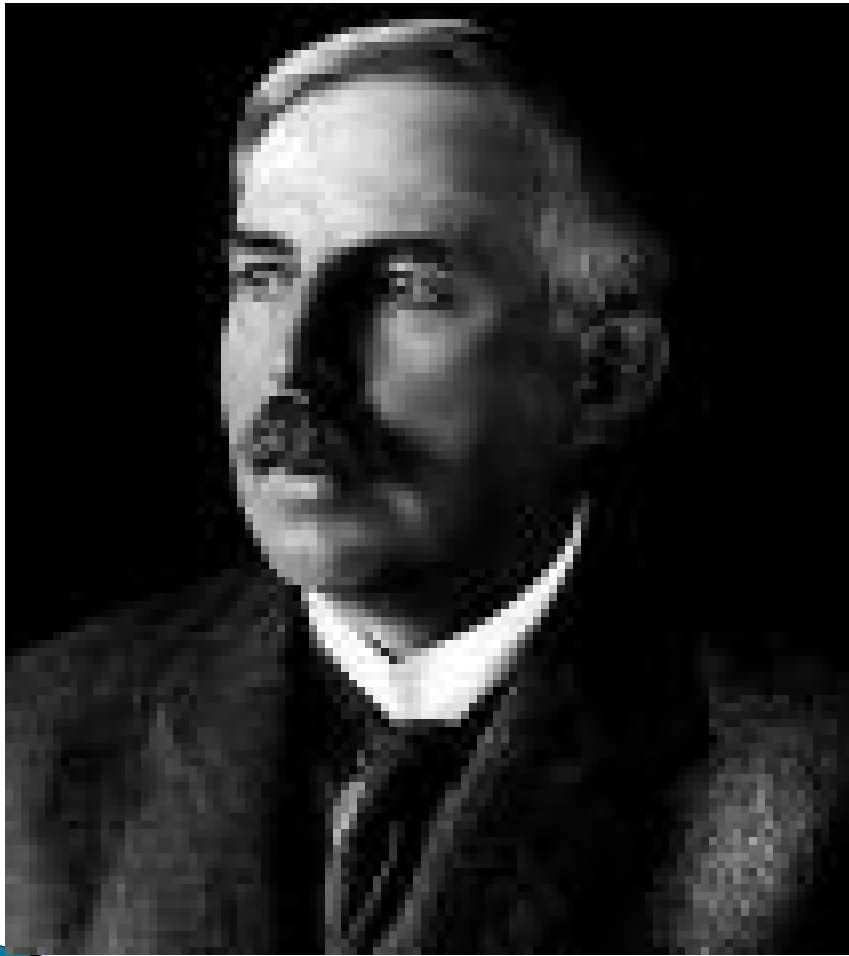
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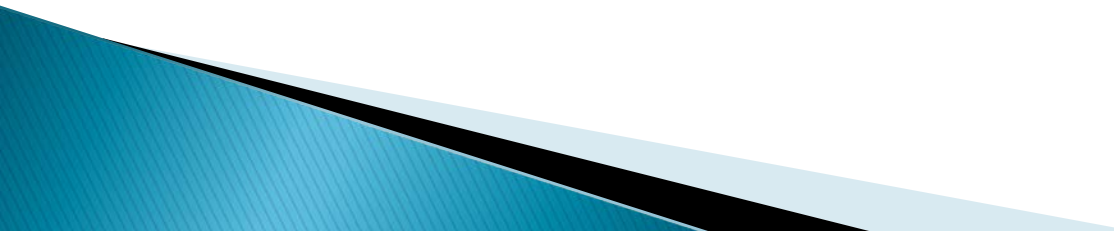


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- ▶ 1908 Nobel Laureate

The Gold-Foil Experiment

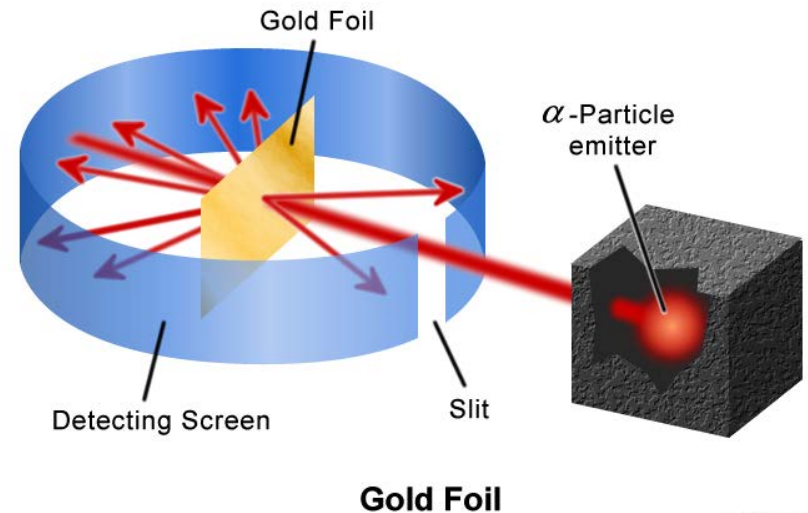
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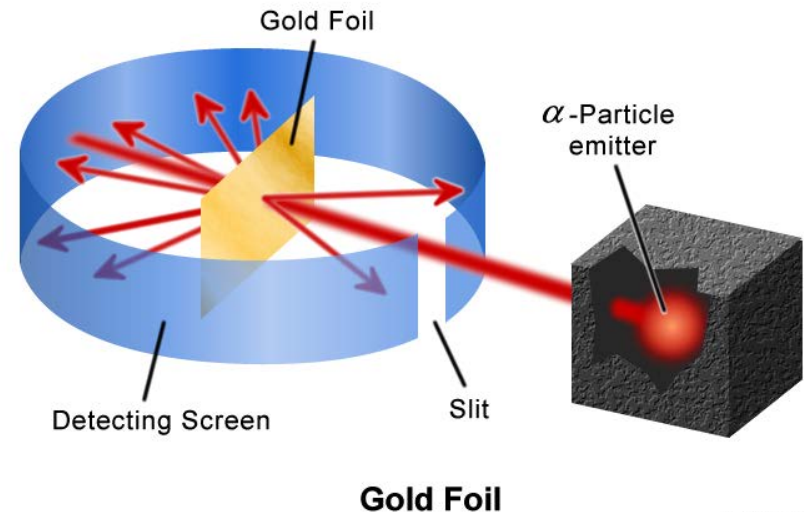
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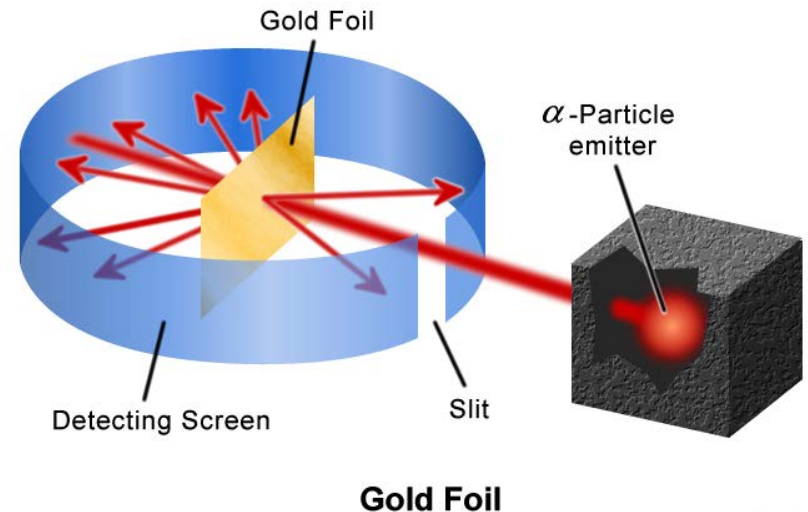
Alpha particles α
big, positively charged particles
Nucleus of a helium atom



The Gold-Foil Experiment

- ▶ Beam of “alpha particles” was directed at thin gold foil and the paths followed by a detection screen

Alpha particles α
big, positively charged particles
Nucleus of a helium atom



Expectations vs. Results

- ▶ If Thomson's model is correct, what should the alpha particles do when they hit the foil?
 - <http://www.wwnorton.com/chemistry/overview/ch3.htm>

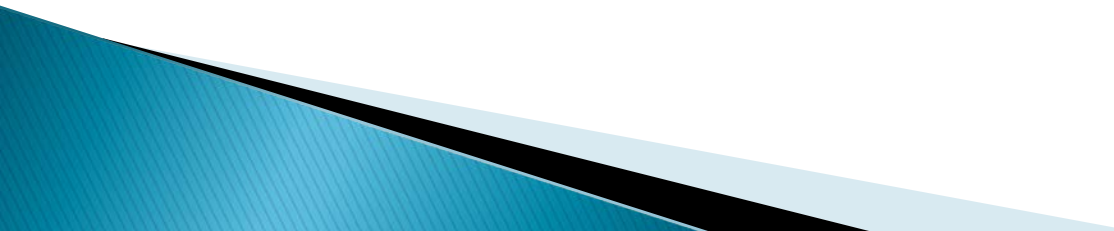
Expectations vs. Results

- ▶ The alpha particles were expected to go straight through the foil

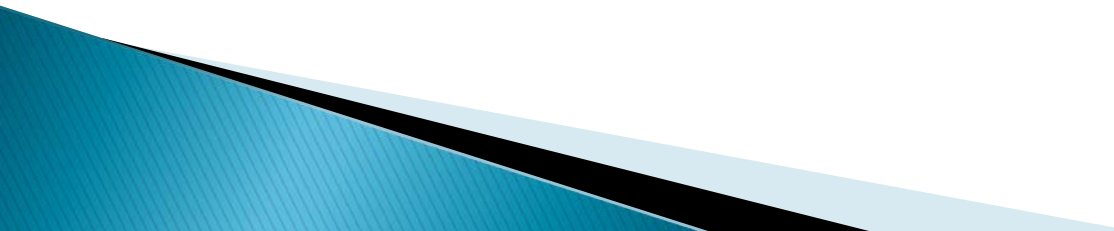
Expectations vs. Results

- ▶ A very small percentage of particles showed “backscattering” when they hit the foil

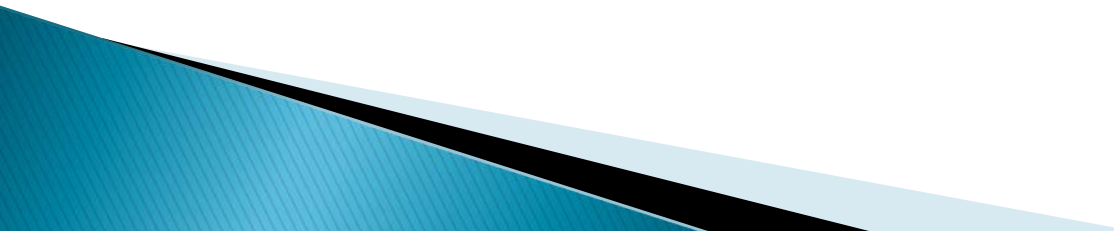
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 - Neutrons were identified in 1932 by James Chadwick

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Rutherford's atomic model

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 - Most of the atom consists of empty space
 - # protons = # electrons in neutral atoms

Robert Millikan

- ▶ U.S. physicist



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- ▶ U.S. physicist
- ▶ University of Chicago



Robert Millikan

- ▶ U.S. physicist
- ▶ University of Chicago
- ▶ Nobel Prize, 1923



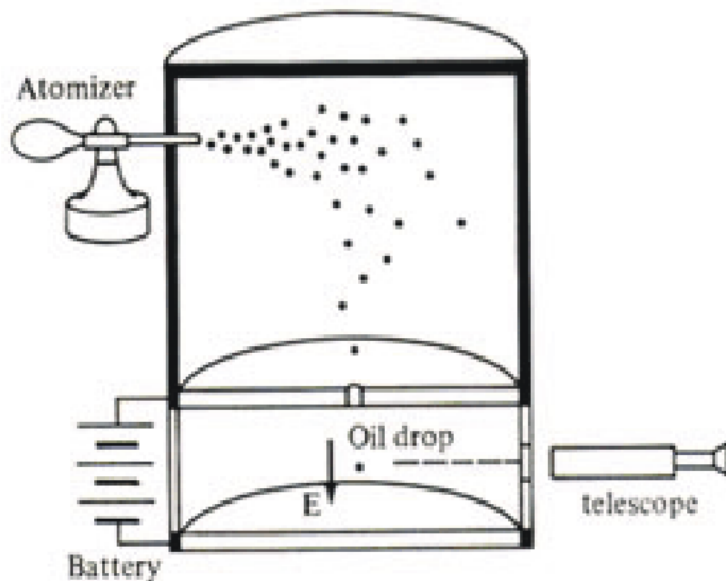
Robert Millikan

- ▶ U.S. physicist
- ▶ University of Chicago
- ▶ Nobel Prize, 1923
- ▶ First major success: finding the charge of an electron

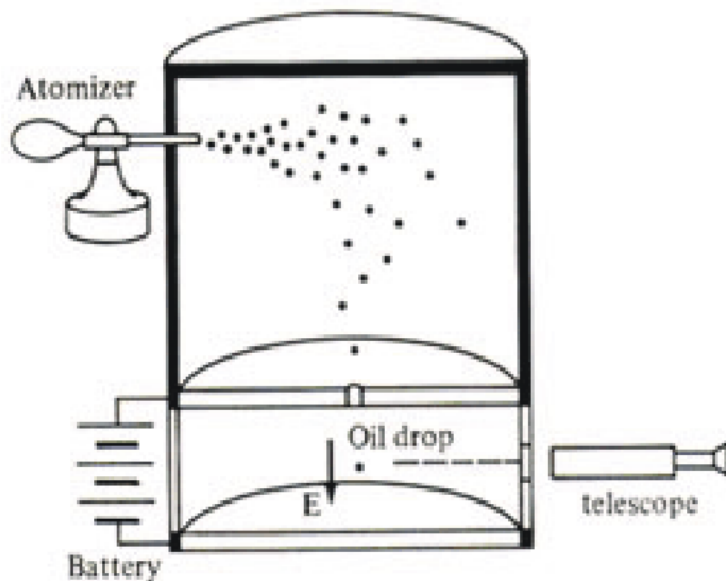


Oil Drop Experiment

- ▶ Millikan determined the charge on an electron

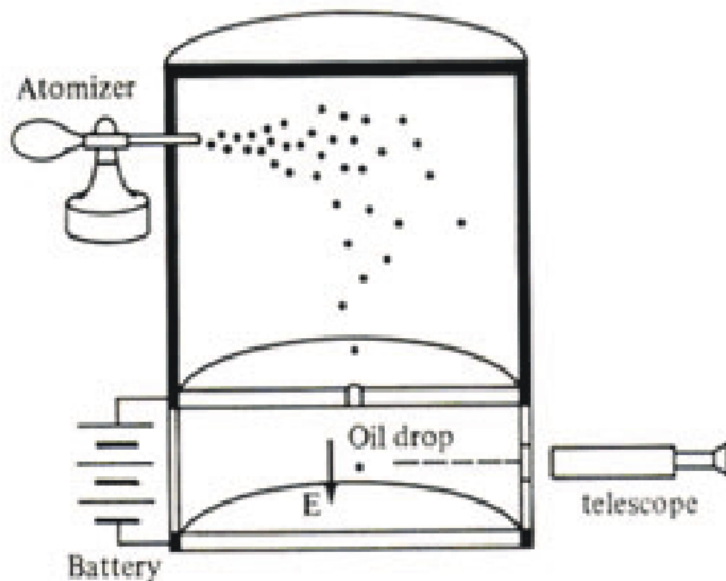


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- ▶ How strong did the electric field need to be to “float” an ionized oil drop?

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- ▶ How strong did the electric field need to be to “float” an ionized oil drop?
- ▶ $Q_c = -1.6 \times 10^{-19}$ coulombs