Robert Millikan Scientific Misconduct

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Early Experiments

- 1896 – J. J. Thomson discovered electron → showed q/m const.
- Measured effect of small E field on charge water droplets
- Crude estimate of q

Robert Millikan

University of Chicago

- Oil-drop expt. published 1910
- Proved charge was discrete.
- Measurement of elementary charge.
- Received the Nobel Prize in 1923.

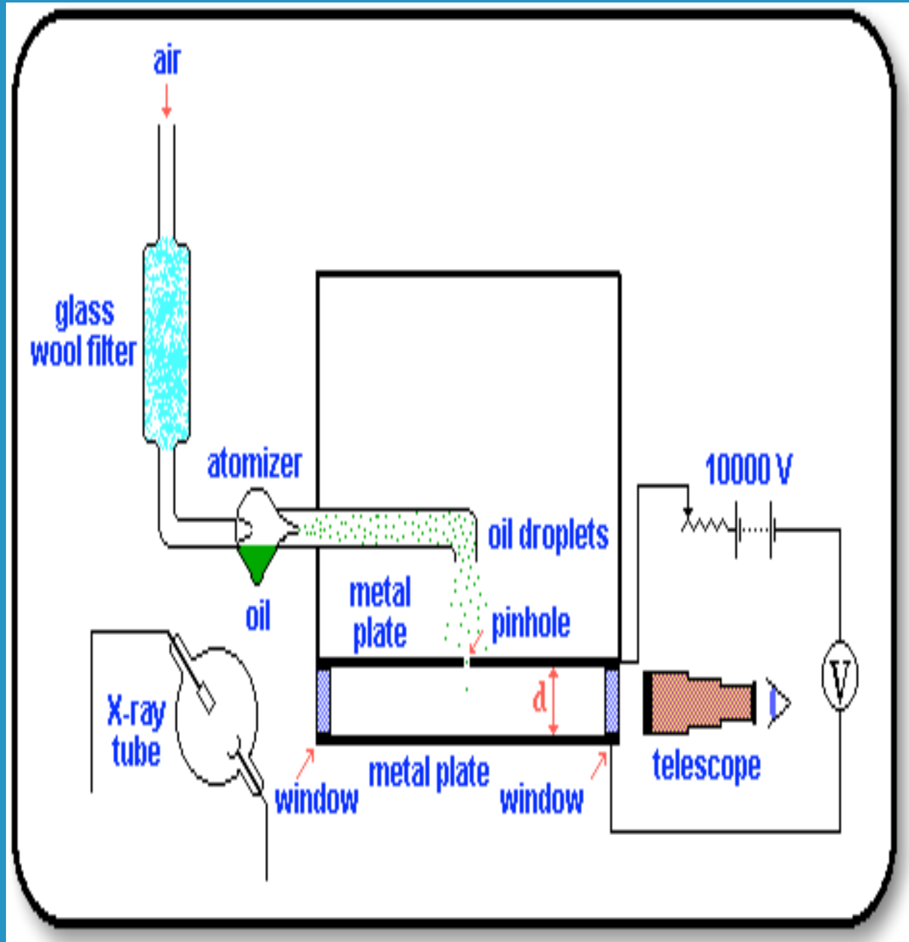
Robert Millikan

University of Chicago

- Two graduate students:
  - Louis Begeman
  - Harvey Fletcher
- Tried expt. with water and large field, but water droplets evap'd rapidly.
- Assigned Fletcher to try other liquids, which he had working very quickly.

Oil-drop experiment

- Droplets ionized by x-ray
- Adjust x-ray to change # of e^-
- Voltage adjusted to suspend drops
- Found charge of drops always quantized



Brownian Motion

- Drops small enough to exhibit Brownian motion
- Large particle (dust, oil droplet) bombarded by fast moving small particles (gas molecules)

Fletcher’s Ph.D.

- Millikan agreed Fletcher could use published paper as thesis,
  - But only if Fletcher was sole author.
- Papers published:
  - Millikan, Measuring charge of e^-
  - Fletcher, Brownian motion

Oil-drop controversy

- Millikan believed to be denied 1920 Nobel Prize
- Felix Ehrenhaft with similar setup measured smaller charges
- 1913 Millikan published measurements with very small range of error.

Oil-drop controversy

- 1913 results report 58 measured drops.
- Lab notebooks reveal 175 drops measured in 5 mo.
- About 75 drops measured in 63 days:
  February 13, 1912 to April 16, 1912
- "It is to be remarked, too, that this is not a selected group of drops, but represents all the drops experimented upon during 60 consecutive days"

Lab Notebook Annotations

- First few drops measured annotated with:
  - “Very low, something wrong”
- Another drop:
  - "This is almost exactly right, the best one I ever had!!!”
  - Not included in 1913 paper
- Others:
  - This is almost exactly right & the best one I ever had!!! [20 December 1911]
  - Exactly right [3 February 1912]
  - Publish this Beautiful one [24 February 1912]
  - Publish this surely / Beautiful !! [15 March 1912, #1]
  - Error high will not use [15 March 1912, #2]
  - Perfect Publish [11 April 1912]
  - Won't work [16 April 1912, #2]
  - Too high by 1½% [16 April 1912, #3]
  - 1% low
  - Too high e by 1¼%

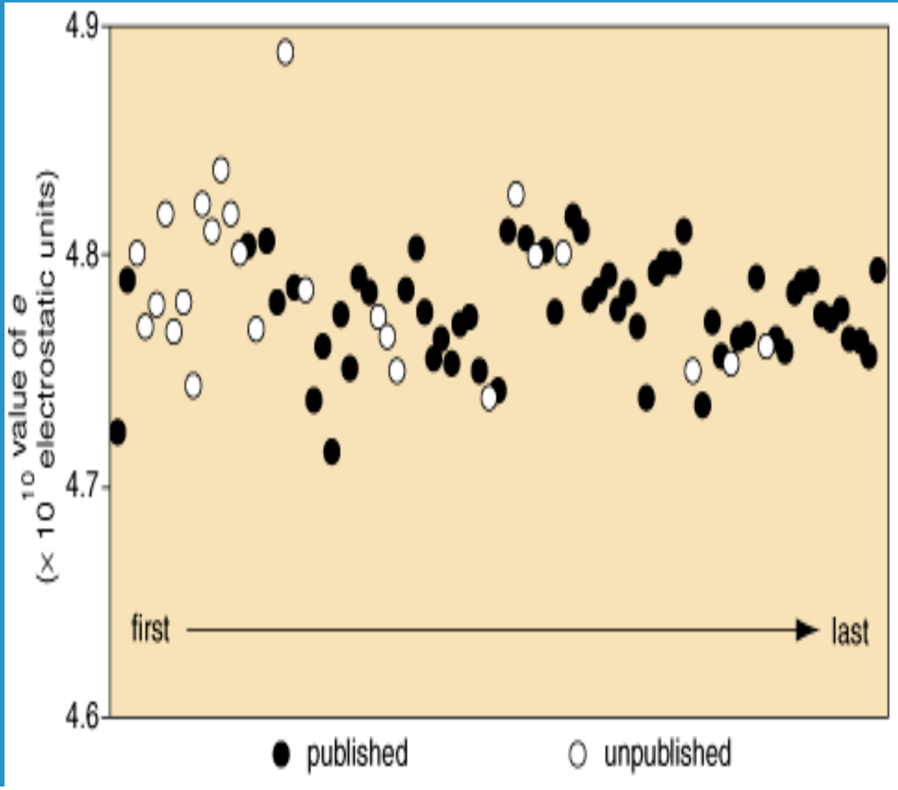
Omission Discovered

- Gerald Holton examined Millikan's notebooks (1970's?), no accusations made.
- Broad and Wade (*Science* reporters) wrote *Betrayers of the Truth* in 1982
  - "[Millikan] extensively misrepresented his work in order to make his experimental results seem more convincing than was in fact the case."

4.80325×10^{-10} electrostatic unit

Discarded Data

- **Drops discarded because:**
  - Too small (too much Brownian motion)
  - Too large (drop falls too quickly)
  - Asymmetrical drop
  - Convection currents
  - Non-uniform field
- **Good and bad data discarded.**
- **More data thrown out earlier.**



Summary

- Authorship on publication w/ graduate student
- Misreporting of data likely from discarding results from poor expt'l procedure.
- "…this is not a selected group of drops…"
- Overzealous journalism

We have learned a lot from experience about how to handle some of the ways we fool ourselves. One example: Millikan measured the charge on an electron by an experiment with falling oil drops, and got an answer which we now know not to be quite right. It's a little bit off because he had the incorrect value for the viscosity of air. It's interesting to look at the history of measurements of the charge of an electron, after Millikan. If you plot them as a function of time, you find that one is a little bit bigger than Millikan's, and the next one's a little bit bigger than that, and the next one's a little bit bigger than that, until finally they settle down to a number which is higher.

Why didn't they discover the new number was higher right away? It's a thing that scientists are ashamed of - this history - because it's apparent that people did things like this: When they got a number that was too high above Millikan's, they thought something must be wrong - and they would look for and find a reason why something might be wrong. When they got a number close to Millikan's value they didn't look so hard. And so they eliminated the numbers that were too far off, and did other things like that. We've learned those tricks nowadays, and now we don't have that kind of a disease.

Feynman - 1974