Observation of the Photoelectric Effect

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History of a phenomenon

Discovery

- Hertz's radio experiments (1886-7)
- Ultraviolet light and electricity

Investigation

- Lenard's experiment (1902)
- Energies independent of intensity
- But dependent on frequency!

Understanding

- Einstein's explanation (1905)
- Light quanta with $E \propto \nu$
- Millikan's experiments (1912-5)

Einstein's theory

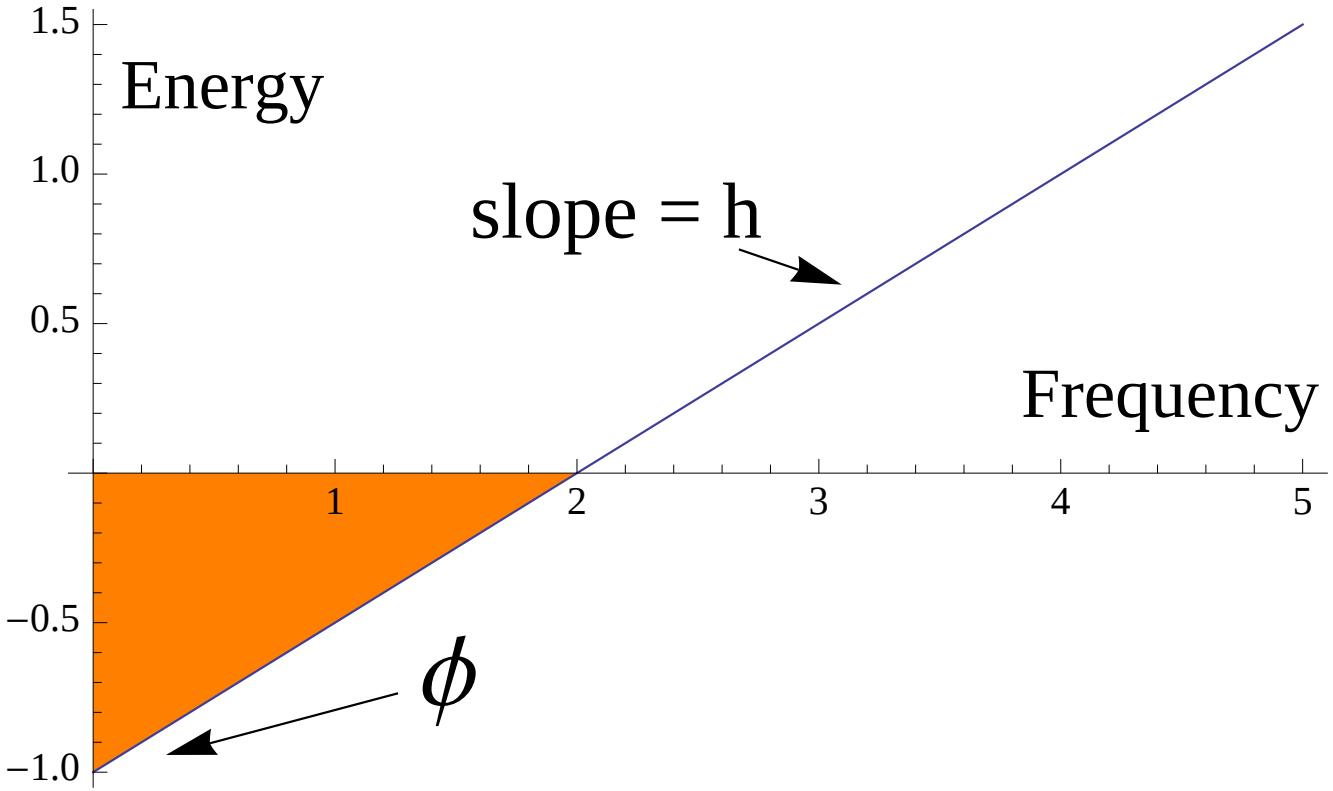
- Planck's quantized oscillators
- Photons, with $E = h\nu$
- Intensity $\equiv$ number of photons
- One photon, one electron

$\Downarrow$

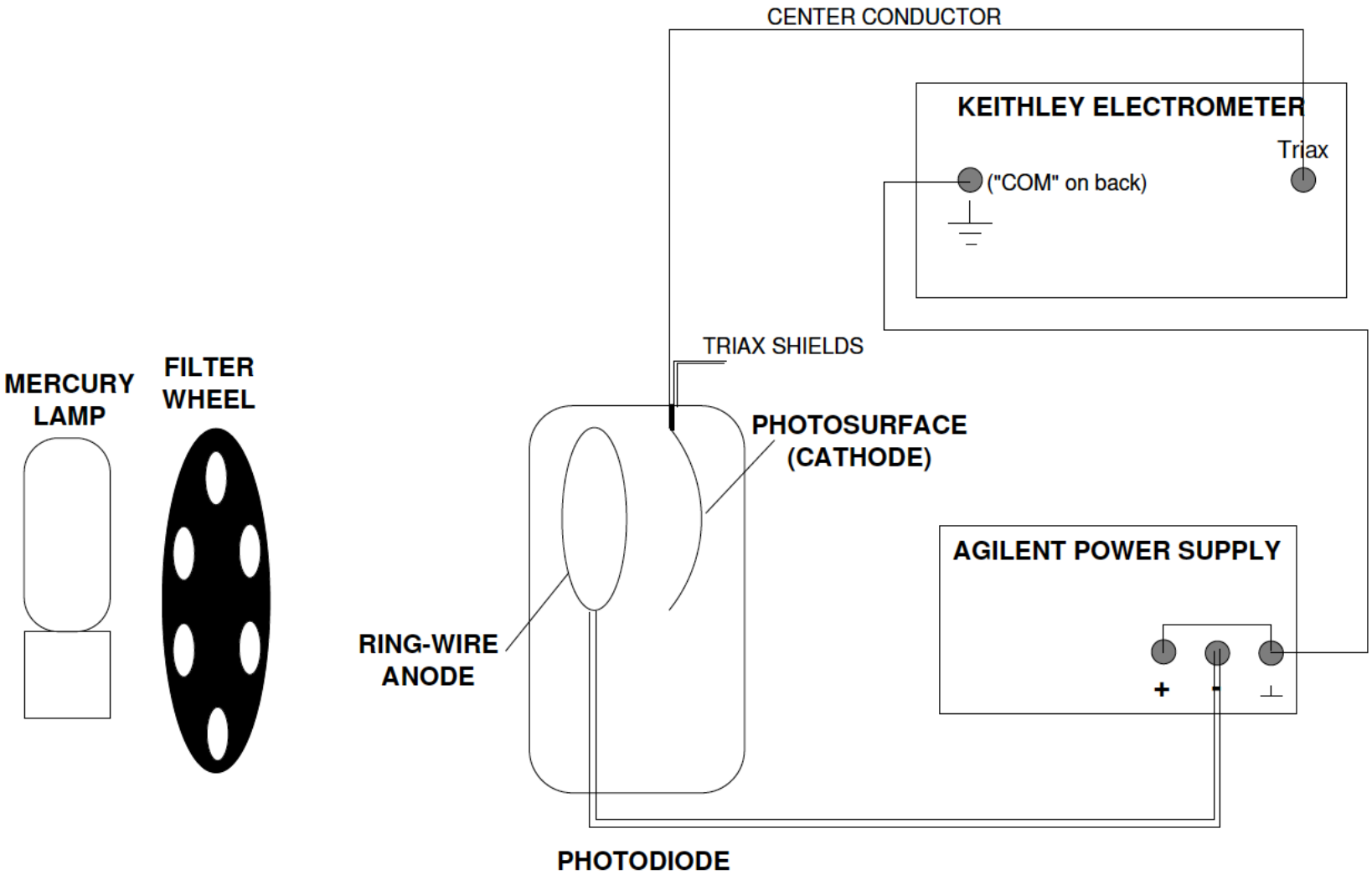
- Energy of emitted electrons independent of intensity
- Energy dependent on frequency
- Minimum cutoff frequency

Einstein's theory

$$KE_{e^-} = h\nu - \phi$$

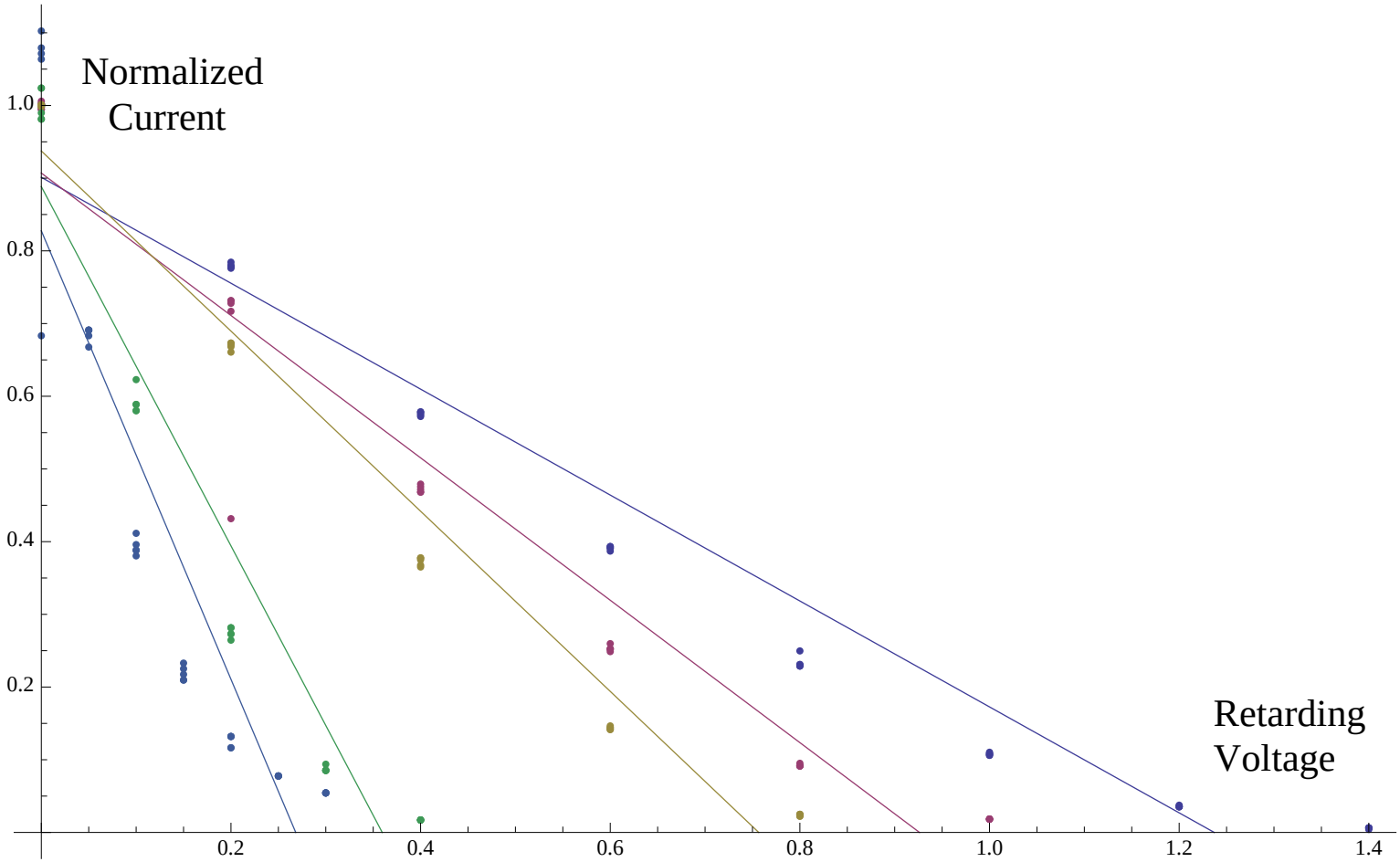


Experiment Setup



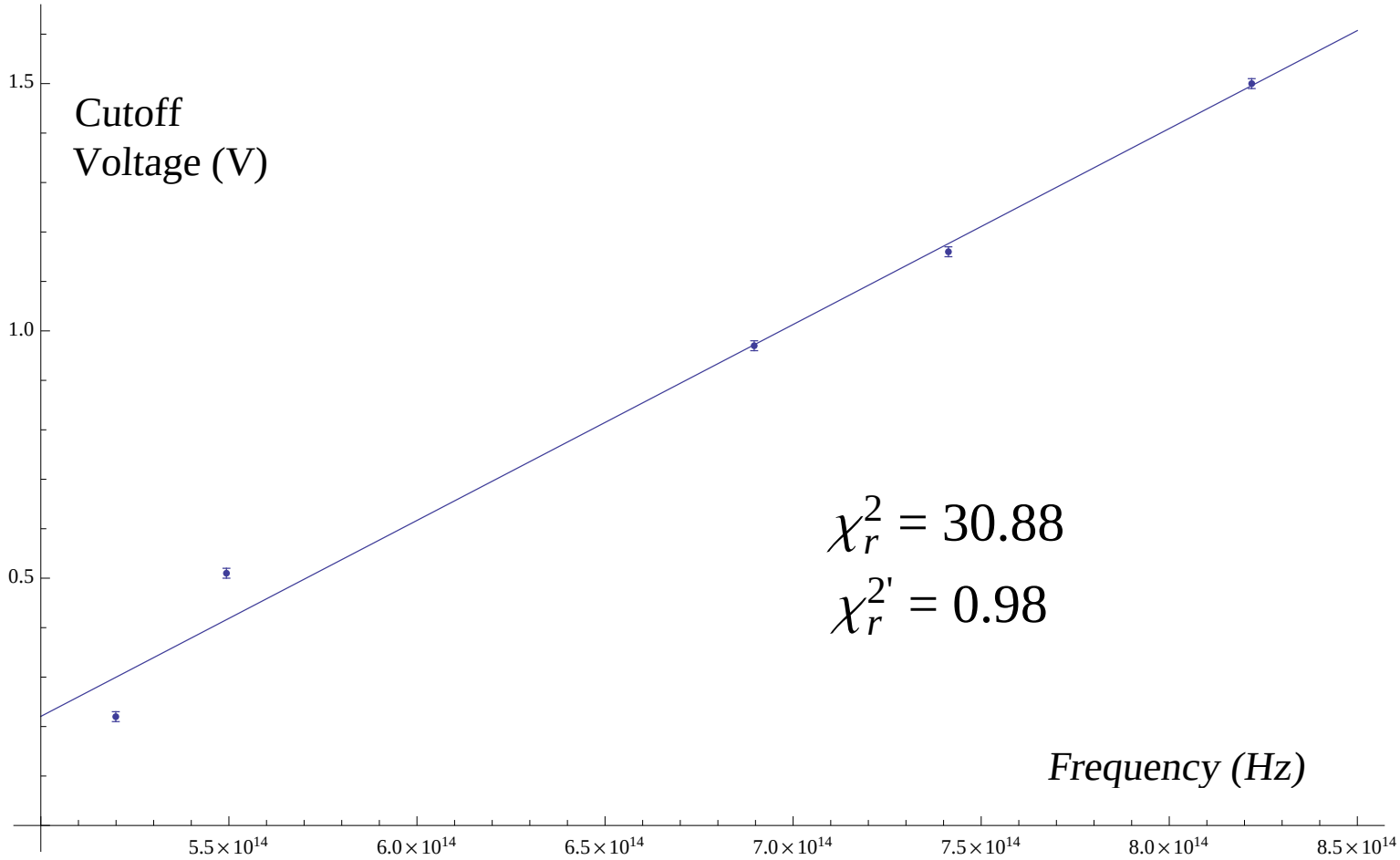
Slightly modified from experiment lab guide (`http://web.mit.edu/8.13/www/intro2.shtml`).

Current vs. Retarding Voltage



- Some expected features, with some extras
- Theoretical model?

Cutoff Voltage vs. Frequency



- Large χ^2 for small ν
- However, near-linear relationship as expected

Results and Errors

- $h = (6.348 \pm 0.0626) \cdot 10^{-34}\ \mathrm{J \cdot s}$
  - $\approx$ 4.2% off of true value ($\approx$ 4.5 times estimated error)
- $\phi = 1.76 \pm 0.026\ \mathrm{eV}$
  - $\approx$ 23% off of true value ($\approx$ 21 times estimated error)

- Random Errors
  - Precision of instruments
  - Small compared to...
- Systematic Errors
  - Ambient light
  - Light striking the anode
  - Cutoff voltage bias
  - Variation of ϕ

- Various possibilities for systematics, but probably not due to measurement error
- Disparity in error makes some possibilities less likely

Summary

- $h = (6.348 \pm 0.0626) \cdot 10^{-34}\ \mathrm{J \cdot s}$
- $\phi = 1.76 \pm 0.026\ \mathrm{eV}$
- Photoelectric effect well described by Einstein's model
  - Linear dependence of cutoff voltage on frequency
- Particle-like nature of light

Questions?