The Photoelectric Effect

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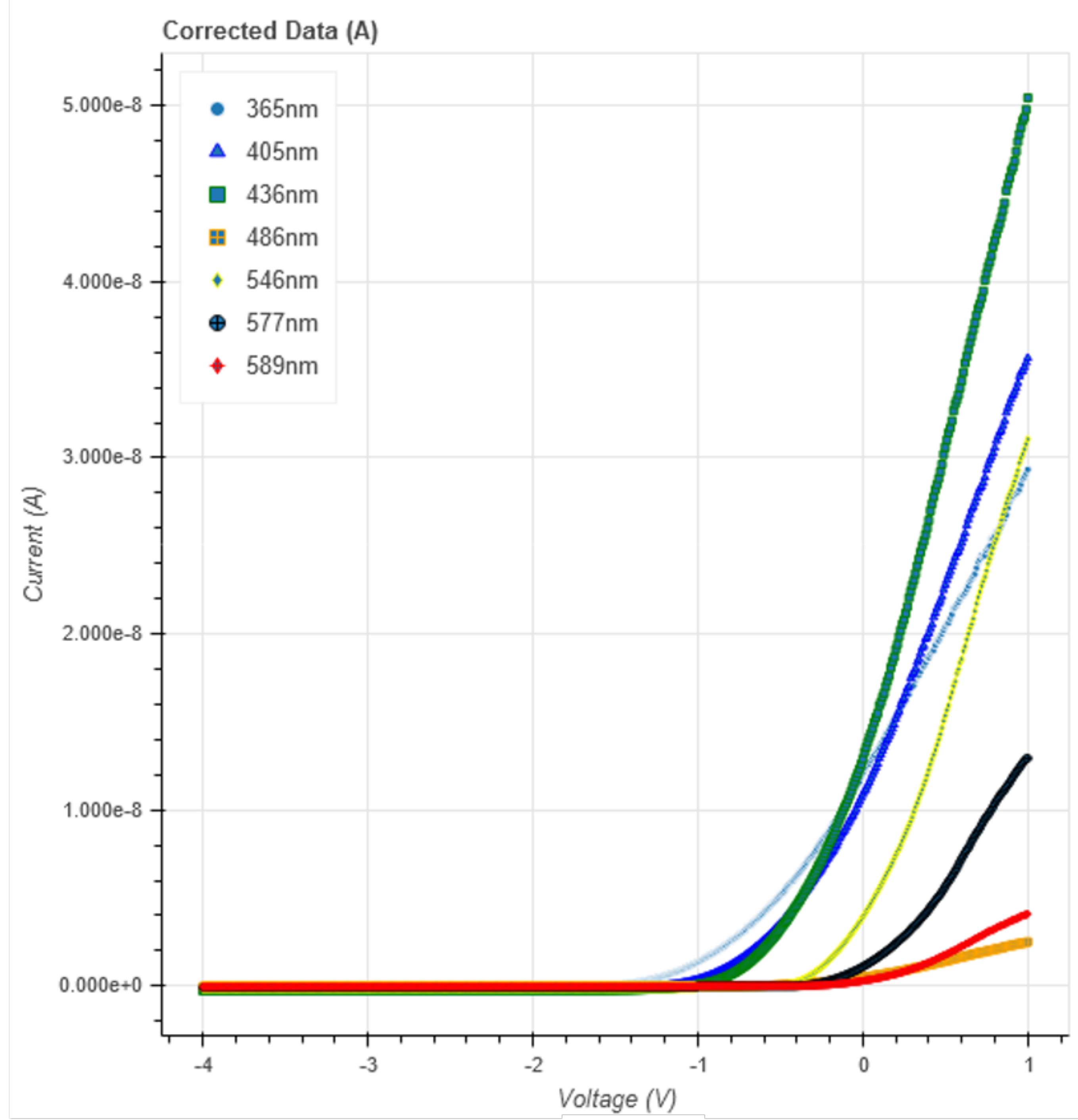
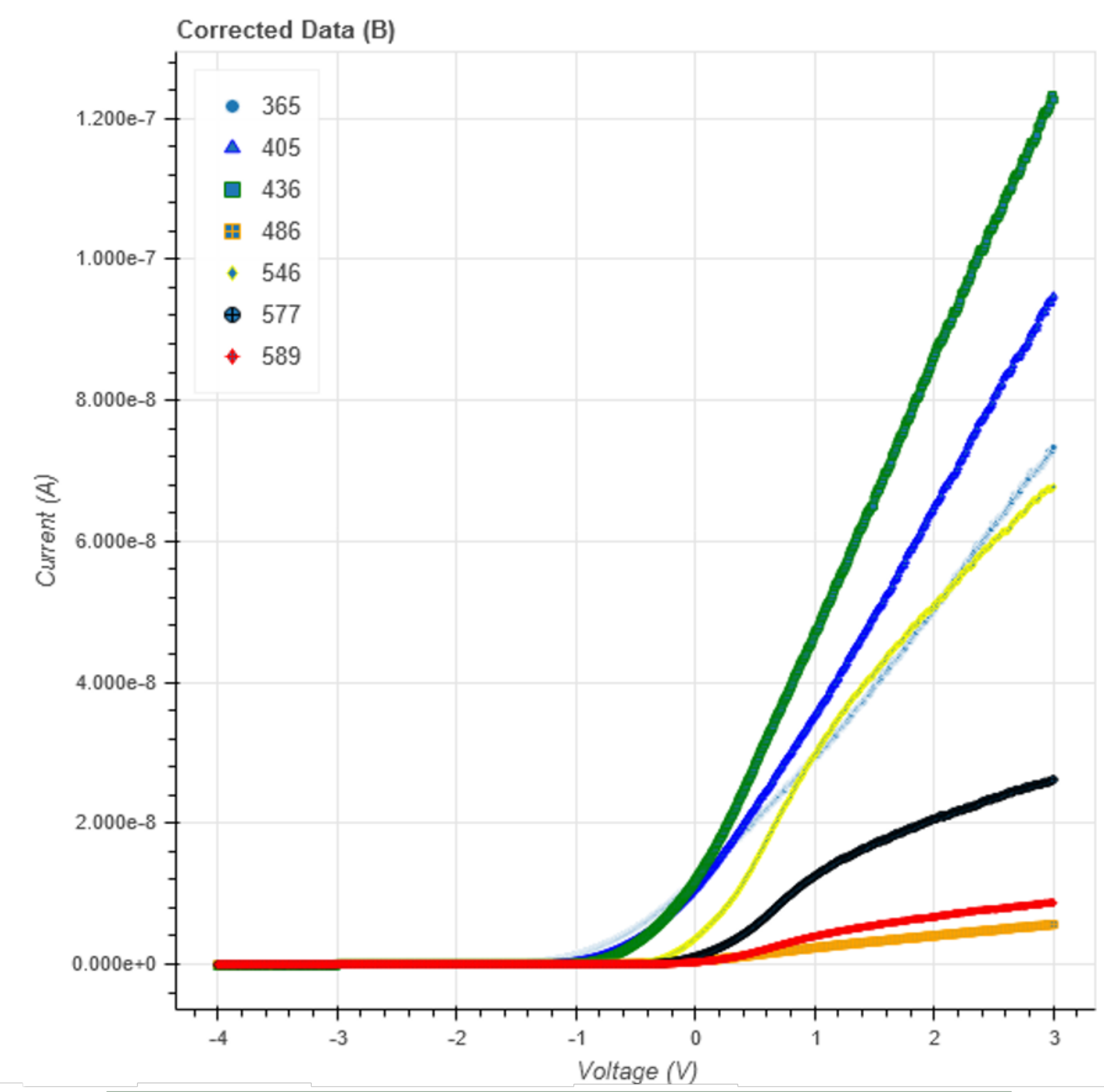
Abstract

The photoelectric effect was an important gateway into our modern understanding of photons' wave-particle duality. We set out to verify Planck's constant and determine the work function of our bulb's cathode. Using various filters and a swept potential, we were able to measure the current of various wavelengths of light from a mercury lamp over a range of voltages. From this current data, we were able to find the stopping potential, and by running a linear fit over all of the wavelengths and their required energies, we calculated Planck's constant using the slope and the work function using the intercept. We found Planck's constant within 3% of the expected value and our cathode's work function to be within the range of that of silver; oxidized silver was the coating used on the cathode. We thus concluded that the coating on the cathode was the primary factor in determining the work function, rather than the base potassium which had a much smaller work function.

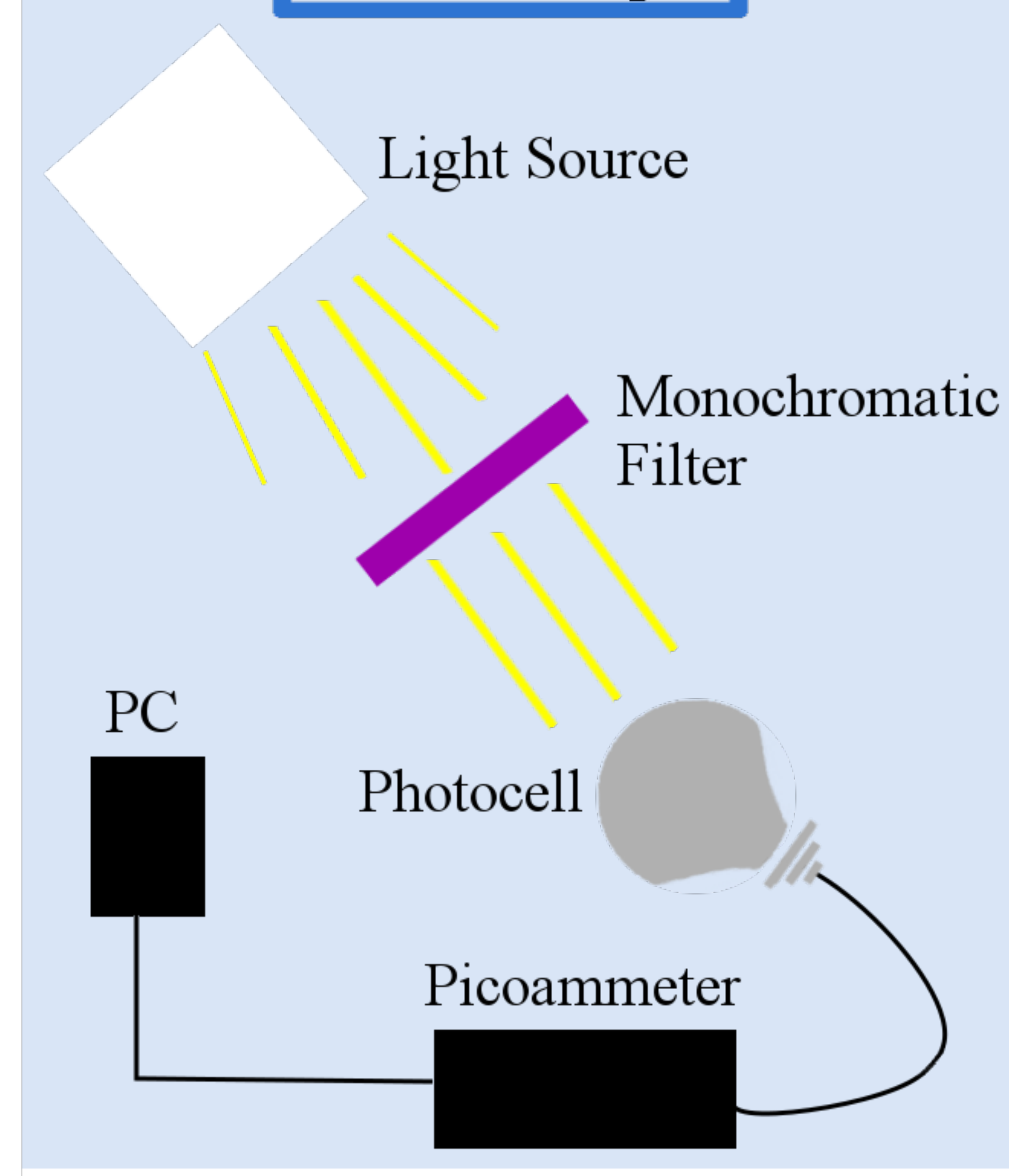
Procedure

We used a mercury lamp as our light source and selected singular wavelengths using filters. The light was shone on a bulb containing a photocathode; the bulb was connected to Keithley for taking electrical data. Current data was taken using a picoammeter as we swept the voltage.





Setup



Differences in Data

$$I(+V) = \frac{I'(+V) - fI'(-V)}{1 - f^2} \qquad f = \frac{I'(-V)}{I'(+V)}$$

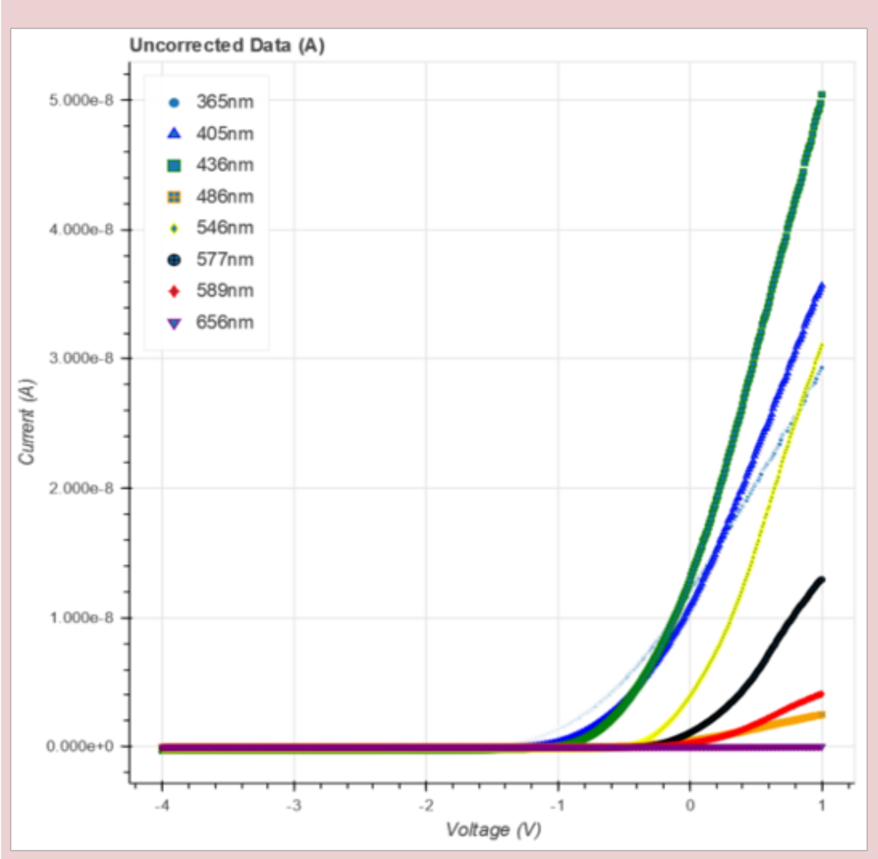
It is worth noting that Run A only collected data from -4 to +1 V, while Run 2 collected from -4 to +4 V. Because the data correction for back current requires a corresponding positive +V for any negative -V, the correction for Run 1 is incomplete, as voltages from -4 to -1.01 do not have an opposite voltage for calculation of the fractional constant *f*. The effect *f* has on the final plot of Vstop vs. frequency is only a vertical shift -- the slope remains unchanged, and is therefore useful in analysis. With this in mind, the intercept obtained from Run A was considered to yield an inaccurate estimation of the photocell's work function; the slope, however, was considered along with that of Run B to obtain an average estimation of Planck's constant.

Final Data

	Expected	Calculated	Error
h	4.14[eVs]	4.04[eVs]	2.5%
φ	4.2-4.7[eV]	4.6[eV]	±0.2

656nm

The 656nm data was nearly zero and consistent with noise, so this data was discarded. The lamp's provided spectrum states that it does not give off significant light at wavelengths greater than 600nm.



Calculation

$E=h\nu \quad E=eV$

After correcting our data, the stopping voltage for each curve was found as the point at which voltage left zero. This point represents the voltage at which electrons can be ejected, so the energy of an electron at this voltage should be equal to the energy expected in the photoelectric effect:

$$V_c e = h\nu - \phi$$

For a cutoff potential V_c, work function ϕ, frequency ν, and Planck's constant h. Using a linear fit to relate our frequency to our cutoff voltage, we were able to find Planck's constant as the slope and the work function as the intercept of the curve.