PHY153 Final project, DUE 05/12/2022 (Thursday)

https://phet.colorado.edu/sims/cheerpj/photoelectric/latest/photoelectric.html?simulation=photoelectric

Project description

Credit: From Stony Brook University: PHY252 THE PHOTOELECTRIC EFFECT)

In this experiment you will use the photoelectric effect to measure the Planck constant h. This classical experiment led to the first precise determination of h, and in 1926 R.A. Millikan received the Nobel Prize for it.

A phototube is illuminated by light of a known wavelength. Electrons are ejected from the photocathode with some kinetic energy K. They are collected as anode current unless a variable retarding potential V is large enough to stop the electrons. For a given potential V all electrons with $K < eV$ will be stopped, and at some value V_0 even the fastest electrons with a kinetic energy K_{max} will be stopped when

$$K_{max} = h\nu - W = e\,V_0\,, \qquad (1)$$

with ν the frequency of the incident light, and W the work function of the cathode material ($W = h\nu_0$). By measuring V_0 for different light frequencies, for a known value of $e = 1.602176634\times10^{-19}$ C, one can determine the Planck constant h.

Write a code to:

Data analysis

1) For each type of cathode material (Na, Pt, Ag, K, Cs):

   a) plot K_{max} versus the frequency ν , fit a straight line according to Eq.1, and from the best fit results determine work function W and h with uncertainties. Use error propagation, if needed. How good are your fits? Quantify by calculating Chi2 ("Sm") and p-value. Round the results.
   b) Compare W's obtained from the fits in a) with W_{true} (given for each material in column 2, Tab.I). Quantify the agreement (or disagreement) by calculating "z" value and corresponding p-value.

   (you should have 5 sets of results a) and b) for 5 different materials)

2) Combine 5 fit results on h (Planck constant) for various types of cathode material, as obtained in part 1) above, to find the best value on h (with uncertainty) , h_{best}, and compare it with the "true" value $h_{true} = 0.4135667696 * 10^{-14}$ [eV*s]. Quantify the agreement (or disagreement) between $h_{best} +/- \sigma_{hbest}$ and h_{true} by calculating the "z" alue and corresponding p-value. Round the results.

Data are shown in Table 1 on the next page. For simplicity, it uses K_{max} already evaluated from V_0 ($K_{max} = e V_0$)

You may reuse your code(s) from previous assignments.

Table I

Cathode material	W_{true} [eV]	ν [10^{14} Hz]	K_{max} [eV] , σ_{Kmax} = 1.0 [eV]
Sodium (Na)	2.3	[4.2 8.3 10.4 12.5 14.6 16.7 18.8 20.8 22.9 25. 27.1 29.2 31.3 33.3 35.4 37.5 39.6 41.7 43.8 45.8 47.9 50.]	[1.0 2.0 3.2 2.7 5.1 4.1 6.1 5.9 8.2 7.8 10.3 8.5 10.2 11.4 13. 13.7 12.9 14.8 16.1 15.7 17.1 19.4]
Platinum (Pt)	6.4	[16.7 18.8 20.8 22.9 25. 27.1 29.2 31.3 33.3 35.4 37.5 39.6 41.7 43.8 45.8 47.9 50.]	[1.9 1.9 1.3 5. 2.8 4.6 3. 4.9 8. 7.3 9.1 10.4 8.6 11.9 13.7 14. 13.1]
Silver (Ag)	4.7	[10.4 12.5 14.6 16.7 18.8 20.8 22.9 25. 27.1 29.2 31.3 33.3 35.4 37.5 39.6 41.7 43.8 45.8 47.9 50.]	[1.5 0.3 2.4 2.6 3.1 3.2 5.4 3.9 7.5 7. 8.5 6.9 9.4 10.5 12.7 13.7 13.6 14.6 15.1 15.]
Potassium (K)	2.2	[6.2 8.3 10.4 12.5 14.6 16.7 18.8 20.8 22.9 25. 27.1 29.2 31.3 33.3 35.4 37.5 39.6 41.7 43.8 45.8 47.9 50.]	[0.9 0.8 1.6 2.5 3.7 5.9 4.3 6.8 9.1 8.8 8.7 10.2 9.4 10.7 13.1 12.1 14.3 15.8 15.2 15.8 17.6 18.8]
Cesium (Cs)	1.9	[2.1 4.2 6.2 8.3 10.4 12.5 14.6 16.7 18.8 20.8 22.9 25. 27.1 29.2 31.3 33.3 35.4 37.5 39.6 41.7 43.8 45.8 47.9 50.]	[0.3 0.4 0.4 2.6 3. 3.3 4.1 5.7 7.2 5.7 6.5 8.8 8. 10.6 10.4 12.1 11.7 13.7 15.9 16.5 15.6 18.1 18.2 18.7]

Report: Latex or Word or Text file or jupyter-notebook file.

Code: zylabs (14.8) or jupyter notebook or python script.

All figures should be created in Python script and included in your report as part of your submission. **YOUR CODE MUST RUN WITHOUT ERRORS!**

The final report should contain the following sections:

1.Project description

2.Data Analysis

3.Results

Include:

a) figures with data points and fit results with uncertainties (rounded) for each element

b) final results with uncertainty (rounded)

4.Conclusion

State what you measured, results and uncertainties. Does result match theory? State why your result is or isn't reliable, what you might do to improve further measurements (such as improving data points uncertainties, increasing the number of data points, etc)

Appendix:

Include your code (can be an attachment or copy paste from ZyLab 14.8.