PHY153 Final Project

THE PHOTOELECTRIC EFFECT

Based on PHY252 lab experiment

Report (Latex *.tex file + pdf file) + Corresponding python code (or codes)

Due: Monday December 16

I. Introduction

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.

II. Data and Analysis

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]

1) <u>For each type of cathode material</u> (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.

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 "f" 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} +/- σ_{hbest} and h_{true} by calculating the "f" value and corresponding p-value.

III. Conclusions.

State what you measured. Do results on h and on W match "true" values? (Quantify your statements) If not, state why your results may not be reliable, and what you might do to improve further measurements.