PHY153 (virtual class)
Today: 04/23/2020 programming lab
J. Kiryluk

Plan of today's class:

1. Straight line fitting, 0423Ex1.py [50% of final project]

DUE date: May 5 (TU)

2. Files [Zybook Ch12 , previous reading assignment]

   In class activities : ZyLabs: 12-7, 12-8,12-9

0423Ex1.py Straight line (2 parameters) fitting – practice
Use your own code / functions to fit g(x) = a*x + b to the data

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

$$\boxed{K_{max} = h\nu - W = e\,V_0\,,} \tag{1}$$

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 = $1.602176634 \times 10^{-19}$ C, one can determine the Planck constant *h*.

g(x) =ax+b, where
x=ν, a=h, b = - W

0423Ex1.py

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.

   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.

Data file as a text file or a table (next page)
https://blackboard.stonybrook.edu/bbcswebdav/pid-5355754-dt-content-rid-42121216_1/courses/1204-PHY-153-SEC01-47443/data_0423202.txt

0423Ex1.py

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] Fit: a= h /10-14= 0.39 +/- 0.02 **b= - W = -1.36 +/- 0.49** Sm=12.85 p-value = 0.88 Wtrue =2.3 compared with fm = 1.89, p-value (Gauss) = 0.058
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]

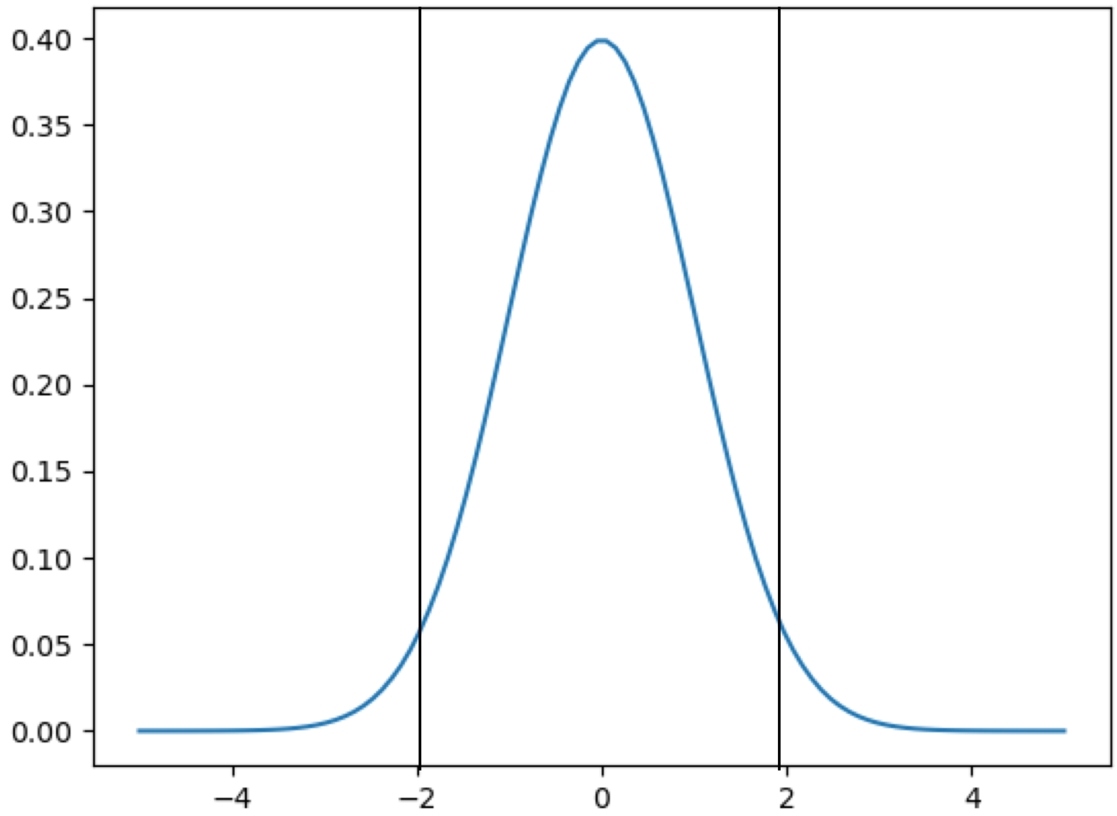
ıybrook.edu/bbcswebdav/pid-5355754-dt-content-rid-42121216_1/courses/1204-PHY-153-
ı23202.txt

```
#Example code how to integrate Gauss function from x=low_lim to x=up_lim

import numpy as np
from scipy.integrate import quad



def myGauss(xl,mul,s2l):
	return np.exp(-(xl-mul)**2/2/s2l)/np.sqrt(2*np.pi*s2l)




mu=0.
s2=1.
low_lim=-2.
up_lim=2.
integral= quad(lambda x,mu,s2: myGauss(x,mu,s2), low_lim, up_lim,args=(mu,s2))
print (integral[0])
```

$$fm = \frac{x-\bar{x}}{\sigma}$$

fm= f-value obtained from an experiment
x- fitted parameter, s uncertainty on the parameter,
$\bar{x}$ – theoretical prediction

Gauss



<u>Example</u>

fm=2
mu=0.
s2=1.

```
integral= quad(lambda x,mu,s2: myGauss(x,mu,s2), -fm, fm,args=(mu,s2))
pvalue = 1 – integral[0]
```