

Plots for Frank-Hertz experiment

1 PLOT LIST

Here is the plot list

1. I – V curves (Current–voltage characteristic) for each cathode heater current (2- 3 values of heater current)
2. Plot I – V curves for 4-5 values retarding voltage V_r
3. I-V curves a couple of temperatures of the FH tube. Lower the temperature to reduce Hg vapor pressure.
4. I – V in semi log scale at low HG pressure (about 120C, depending on the FH tube) to facilitate ionization. Pay attention to a small current rise at low temperatures. Try to explain.

2 DATA IMPORT

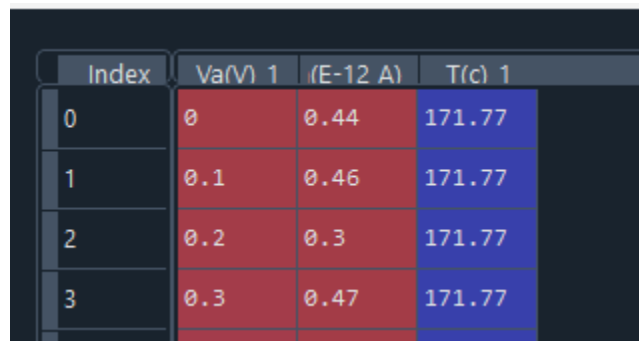
First you need to load the measured data stored as comma-separated values in, say, “FH1.csv”. This can be accomplished by “Pandas” package in Python. In order to use the Pandas package, you need to import it in the import section.

```
import pandas as pd
```

To read the data in the file you can use:

```
fh1 = pd.read_csv('FH1.csv', sep='\t', header=5)
```

About this function you can read [here](#). '\t' stays for tab separator between columns. The function starts to read from line 5 that contains the column names. You can see in variable 'fh1' at the variable explorer, as here at Fig. 1:



Index	Va(V) 1	(E-12 A)	T(c) 1
0	0	0.44	171.77
1	0.1	0.46	171.77
2	0.2	0.3	171.77
3	0.3	0.47	171.77

Figure 1 'fh1' variable.

3 DATA NUMBER FORMAT

To create an accelerating voltage value array from the variable “fh1” we can see the names of columns in fh1 in the console section by

```
print(fh1)
```

This gives something like what you see in figure 2. Take the names of the columns, and create relevant variables:

```
Va1 = np.array(fh1['Va(V)_1']) # accelerating voltage vector
I1 = np.array(fh1['Ia(E-12 A)_1']) # Current vector
T1 = np.array(fh1['T(c)_1']) #temperature vector
```

```
In [8]: print(fh1)
      Va(V)_1  Ia(E-12 A)_1  T(c)_1
0      0.0      0.44      171.77
1      0.1      0.46      171.77
2      0.2      0.30      171.77
3      0.3      0.47      171.77
4      0.4      0.32      171.77
```

Figure 2 fh1 variable in console. Note the underscore that we didn't see in variable explorer

4 DATA PLOT

Now, you can actually plot using the appropriate class. In import section you need to add

```
import matplotlib.pyplot as plt # for plotting figures and setting
their properties
```

To plot a simple I – V curve from our data we need to

1. Define new figure:

```
plt.figure()
```

2. Plot the data in (x,y) form and add appropriate label

```
plt.plot(Va1,I1, label='Heater Current {:.2f}'.format(Heater_Current))
```

when the heater current for this plot stored in variable with name “Heater_Current”. Here we can add another line if we want to plot another line on the same axis.

3. Add an X and Y labels.

```
plt.ylabel('Current [pA]')
plt.xlabel('Acceleration voltage [V]')
```

4. To place the line labels on the plot use:

```
plt.legend()
```

The resulting code

```
#%% Class import section
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

```
### I - V curve heater current

Heater_Current = 0.25 #A
fh1 = pd.read_csv('FH1.csv', sep='\t', header=5) # read the data.

Va1 = np.array(fh1['Va(V)_1']) # accelerating voltage array
I1 = np.array(fh1['Ia(E-12 A)_1']) # Current array
T1 = np.array(fh1['T(c)_1']) #temperature array

plt.figure()
plt.plot(Va1, I1, label='Heater current {:.2f} [A]'.format(Heater_Current))
plt.ylabel('Current [pA]')
plt.xlabel('Acceleration voltage [V]')

plt.grid()
plt.legend()
```

And the result of this

