Franks-Hertz Experiment

Experiment Findings · January 2017

3 authors, including:

Rachel Berube
Bishop's University

Bishop’s University
Intermediate Physics Lab
PHL 385/PHL 387
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Danielle Guillemette
Dario Cattelan
Rachel Berube

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Introduction:

The Franck-Hertz Experiment is a lab that demonstrates that energy is quantized in atomic interactions. The Franck-Hertz experiment was originally conducted to study energetic electrons that were passed through mercury atoms and find the line between elastic and inelastic collisions. From this, the German physicists, James Franck and Gustav Hertz, discovered that when the electron collided with the mercury atom, the gas only absorbs the electrons energy at discrete, quantized energies. This correlates with the Bohr model for atoms that displays the existence of discrete energy levels. Thus through this experiment one can determine what these energy levels are.

Theory:

In 1914, Franck and G. Hertz performed the experiment that would later in 1925 lead them to a Nobel Prize. This experiment provided support to Planck's quantum theory and for Niels Bohr's model of the atom. For Franck and Hertz demonstrated that energy is quantized in atomic interactions.

Bohr's theory proposed only discrete orbits of electrons are allowed, stating that if the electron stays in its orbit it does not radiate any energy and thus is stable. His theory also mentions that electrons cannot exist anywhere between these orbits for it must stay in its discrete energy levels. For the electrons to change orbits he proposed that if it were to go to a lower orbital shell the electron would lose energy in the form of light, thus energy would be conserved. Additionally, to jump up a shell the electron would need a certain amount of energy added to the system to make it to the next orbital path, figure 1. This is displayed throughout the following experiment.

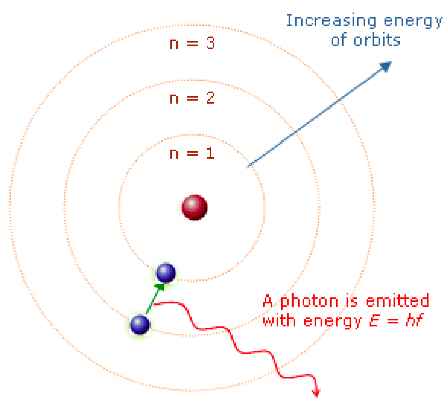


Figure 1- Bohr's Model

This experiment is conducted in an oven-heated vacuum tube that contains a gas, a cathode, a positively charged grid, and a slightly negatively charged collecting plate, as seen in Figure 2.

From thermionic emission, electrons are accelerated from the cathode, through the gas, where they pass through a positively charged grid with enough speed to continue past a retarding force, which is produced from the slightly negatively charged collector plate and once they reach the plate, the electrons are recorded by a multi-meter as current. Assuming all is elastic with in the system (I_c).

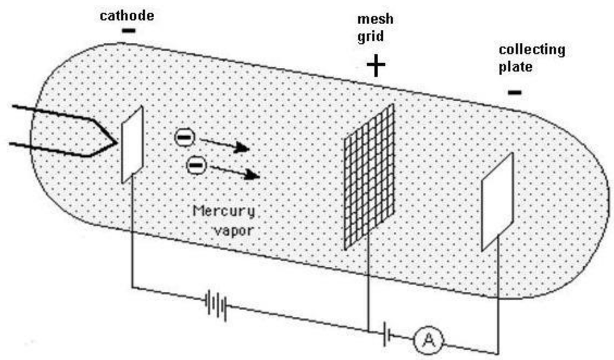


Figure 2- Vacuum Tube

The chance of the electron reaching the collecting plate is dependent on the accelerating potential (V_a), the opposing potential (AV), and the nature of the collisions between the electrons and the gas molecules. When the electron collides with the gas at a low accelerating potential they have an elastic collision, for the kinetic energy of the incoming electrons are not enough to make the electrons in the atom jump up an energy level, therefore the electrons keep all their kinetic energy and are able to make it through the system to the collector plate. This, in turn, produces a current.

This will happen until the discrete energy levels are reached and the collisions become inelastic, for the electrons will induce ionization in the gas. Once the incoming electrons have a kinetic energy greater than the energy needed to jump to the next energy level they experience inelastic collisions and the kinetic energy of the electron will be lost to the gas atoms. The electrons that are left after these collisions will have a very small additional potential as they reach the mesh and thus stick to the positive mesh grid, or else the ones that do make it through won't have enough energy to make it past the retarding force. This makes the current drop until the acceleration continues to rise and the next energy level is reached.

These energies can be found to have an exponential sine relation as the accelerating potential is increased (figure 3). This is a result of the acceleration continuing to rise with the current but now with even more electrons for the system has gained electrons from the previous ionizations.

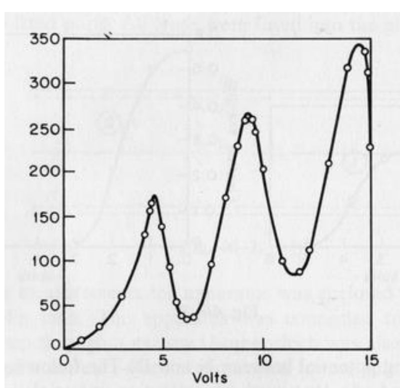


Figure 3: Image from original Franck-Hertz experiment

This suggests that the mercury electrons cannot accept energy until it reaches a certain level that allows them to be elevated to an excited state. For mercury this current drop is at multiples of 4.9eV. At the next level of 9.8eV, each electron gets enough energy to participate in two inelastic collisions and so on.

During inelastic collisions, the lost kinetic energy of the electron is deposited into the electron of the mercury atom. The electron then jumps to an unstable elevated state, then back down to return to its original stable state. This de-excitement of the electrons produces the light in the vacuum tube (figure 4). Franck and Hertz reported that the wavelength of the light corresponds directly to the energy that the de-excited electron had lost. For mercury, this wavelength is 253.7nm, which, corresponds to the ultraviolet spectrum.

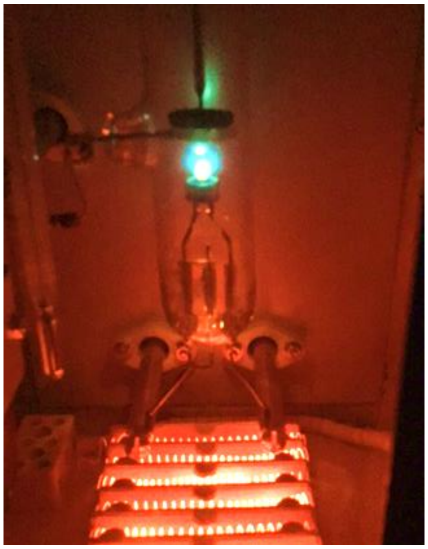


Figure 4: Light Emission

Once we know the energy imparted by the collision, the spectral frequency corresponding to this energy is can be found by the Einstein-Planck relation:

$$1)\ \ \nu = \frac{E}{h}$$
$$where\ h\ is\ Planck's\ constant = 4.133 \times 10^{-15} eVs$$

Thus the corresponding wavelength can be found through the following equation.

$$2)\ \ \lambda = \frac{c}{\nu}$$

Theoretically mercury, that has an energy increment of 4.9eV, thus it would correspond to a light with a wavelength of 254nm.

Objective:

The objective of the Franck-Hertz experiment is to experimentally demonstrate how the Xenon and Mercury gas only absorbs the electrons energy at discrete, quantized levels. This is determined by measuring the strength of the current and noting where there is a current drop. This drop shows when the collisions between the electrons and the gases changes from elastic to inelastic collisions. Mercury is more commonly used for this experiment for it is a monoatomic vapour and it is easy to control its vapour pressure.

Procedure:

Part A:

For Part A of this experiment you will need:

i.) The Frank Hertz Experiment Board
ii.) A 12 V/24 V.DC power supply and a 6.3 V.AC supply.
iii.) 2 Voltmeters/Ammeters

1.) Begin by connecting your 6.3 V.AC supply to the Frank Hertz Board where indicated.
2.) Connect the 12 V/24 V.DC supply, voltmeter, and the ammeter where indicated, just as done for the 6.3 supply. If using adjustable power supplies, it's recommended to hook up additional voltmeters to the voltage suppliers to ensure they are at the needed voltages and stay at these values.
3.) Set the voltmeter scale to 20V and the ammeter to 2m
4.) Turn the voltage adjust knob to zero and the filament knob to max.
5.) Double check all connections are in their proper place before turning the Frank Hertz Board on. When turning on the board switch to experiment 1.
6.) Record the initial voltage and amps on the voltmeter and ammeter.
7.) Proceed to record the voltage and amps as you increment the voltage by .25 V using the volts adjust knob. Do not exceed 11 volts as this will cause collisions past the first excitation state, which will affect results of the overall experiment.
8.) Once data collection is completed, go onto analyzing and graphing your data. The first excited state of Xenon should be easily visible in your graph.

Part B (I & II):

For Part B (I & II) you will need:

i.) A Franck Hertz Oven with bulb of gas, in our experiment it was mercury
ii.) A Control Unit
iii.) Thermometer

iv.) Heat protectant gloves
v.) Oscilloscope
vi.) 2 Voltmeters

I.)

1.) Connect the oven to the control unit and connecting the control unit to the oscilloscope. Then connect the voltmeters to the system, one will be connected to the voltage and H on the control unit (the heater and the signal out) and set 0-1 V.DC. The other voltmeter will be connected to K and A (the cathode and anode) and set for 0-30 V.DC.
2.) Connect the oscilloscope to the system, plug the y-input into the FH Signal Out and the x-input into Va/10 X-Sweep Out on the control unit.
3.) Turn on the oven and allow it to heat up to 180^{o} C, this will take about 10-15 minutes depending on the oven being used. Do not allow the oven to exceed 205^{o} C otherwise the bulb may be broken.
4.) Once the oven reaches 180^{o} C, set the control unit to following settings:
    a. Heater: Midrange ($\cong$ 5.5V)
    b. Amplifier:
        i. Gain : midrange
        ii. Zero : midrange
    c. Va:
        i. Adjust is not applicable
        ii. Switch-ramp
5.) Allow the cathode to warm up for 90 seconds after the oven reaches desired temperature. Then turn on the oscilloscope, set the x-channel and y-channel gain to about .5 volts per cm. An image similar the one below:

II.)

1.) Use the same set up as used in Part A I, except without the oscilloscope.
2.) Set the amplifier to zero.
3.) Turn on the oven, set the temperature to 180^{o} C and allow it to heat up for 10-15 minutes, do not allow the oven to exceed 205^{o} C.
4.) Begin to turn the Va knob clockwise, raising it in increments of 0.5 volts at a time. At each increment record the amplifiers output value. This value recorded is not the current but is proportional to the current.

Observations Part A :

Table 1 : Voltage vs Current

Voltage (V)	Current (mA)
0.00E+00	1.14E-01
2.50E-01	1.69E-01
4.90E-01	2.13E-01
7.60E-01	2.57E-01
1.00E+00	2.86E-01
1.50E+00	3.24E-01
2.00E+00	3.26E-01
2.50E+00	2.98E-01
3.01E+00	2.62E-01
3.50E+00	2.26E-01
4.00E+00	1.95E-01
4.50E+00	1.73E-01
5.01E+00	1.55E-01
5.51E+00	1.42E-01
6.00E+00	1.33E-01
6.51E+00	1.25E-01
6.89E+00	1.21E-01
7.26E+00	1.20E-01
7.50E+00	1.19E-01
7.75E+00	1.18E-01
8.00E+00	1.18E-01
8.25E+00	1.18E-01
8.51E+00	1.19E-01
8.75E+00	1.20E-01
8.99E+00	1.21E-01
9.50E+00	1.24E-01
9.99E+00	1.29E-01
1.05E+01	1.34E-01
1.09E+01	1.38E-01

Table 2: Chosen Points for Regression

Voltage (V)	Current (mA)
4.00E+00	1.95E-01
4.50E+00	1.73E-01
5.01E+00	1.55E-01
5.51E+00	1.42E-01
6.00E+00	1.33E-01
6.51E+00	1.25E-01
6.89E+00	1.21E-01
7.26E+00	1.20E-01
7.50E+00	1.19E-01
7.75E+00	1.18E-01
8.00E+00	1.18E-01
8.25E+00	1.18E-01
8.51E+00	1.19E-01
8.75E+00	1.20E-01
8.99E+00	1.21E-01
9.50E+00	1.24E-01
9.99E+00	1.29E-01
1.05E+01	1.34E-01
1.09E+01	1.38E-01

Figure 5 : Xenon Excitation Voltage

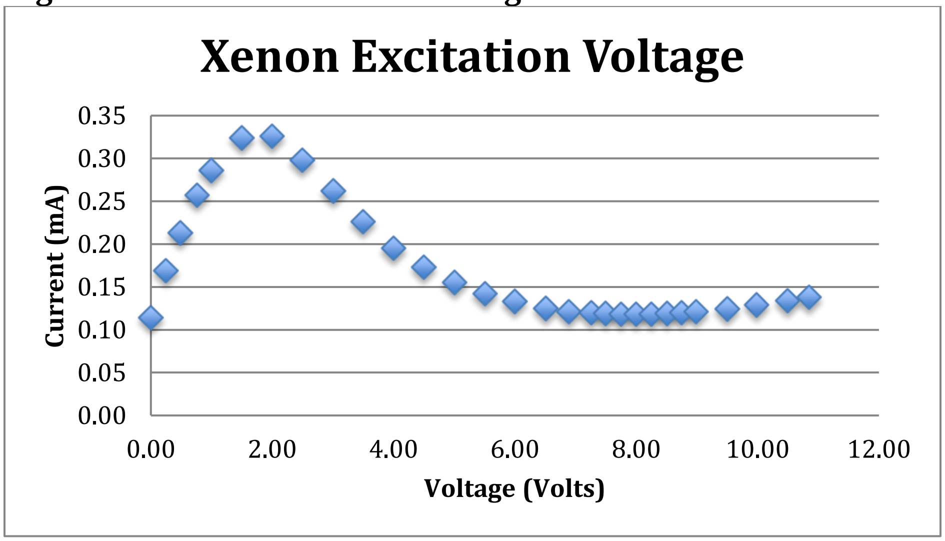
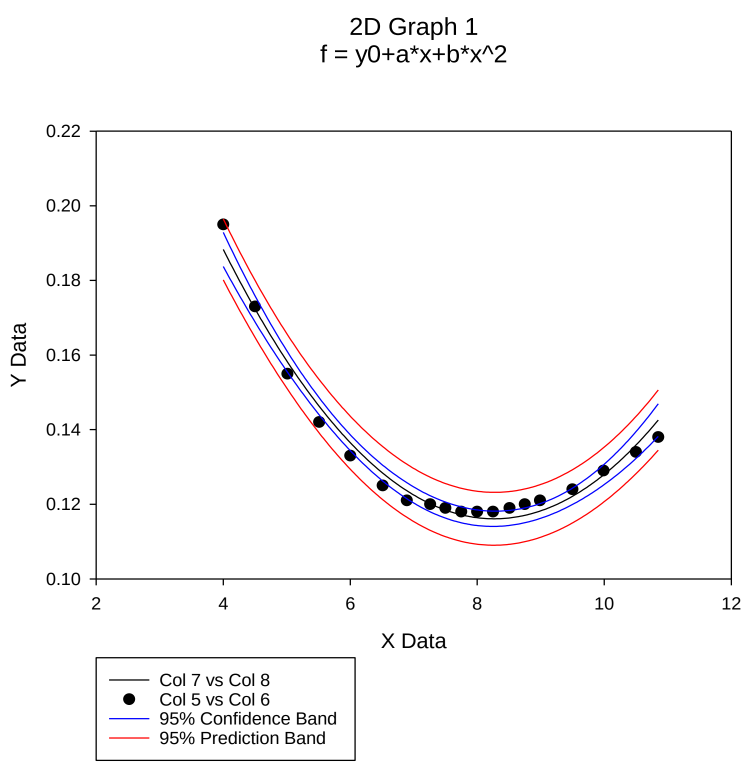


Figure 6: Sigma Plot Regression for Xenon Gas



Interpolation :

$$I \cong (0.0040 \pm 0.0002) * V^2 - (0.0655 \pm 0.0028) * V_a + 0.3871 \pm 0.0101$$
$$I' \cong (0.0080 \pm 0.0004) * V_a - (0.0655 \pm 0.0028)$$
$$V_{center} = 8.20 \pm 0.54V$$

Observations Part B I :

Table 3: Difference Between Peaks Read by Oscilloscope

Va (V)	Uncert. (V)	Diff. (V)	Uncert. (V)
3.0	1.0		
7.5	1.0	4.5	1.0
12.5	1.0	5.0	1.0
17.5	1.0	5.0	1.0
23.0	1.0	5.5	1.0
Average		5.0	1.0

Table 4: Final Excitation Energy and Wavelength of Mercury Atom

	Value	Uncert.	Accepted Value	Percent Error (%)
Energy Difference (eV)	5.00	1.0	4.9	2
Spectral Frequency (Hz)	1.21E+15	6.05E+13	1.18E+15	2
Wavelength (nm)	247.98	12.40	253.7	2

Observations Part B II :

Table 5: Frank Hertz Results for Mercury Oven

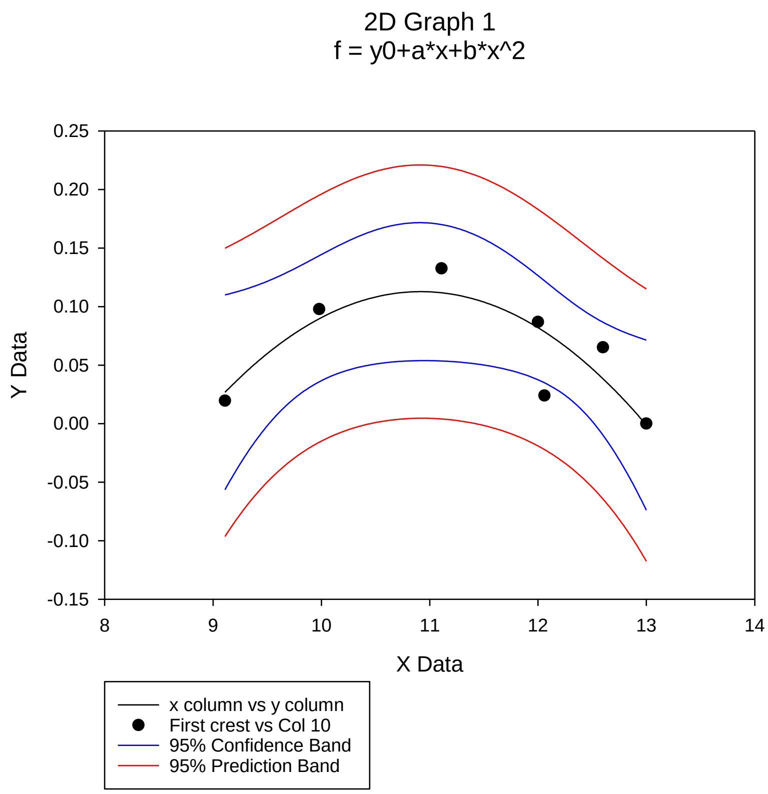
V_a (Volts)	$\propto I_c$ (Volts)	$\propto I_c$ $Normalize$	Temp (Celsius)	Temp Normalized
0.000E+00	0.000E+00	0.000E+00	1.880E+02	9.171E-01
2.100E-01	-8.000E-03	-1.739E-02	1.850E+02	9.024E-01
9.400E-01	-1.500E-02	-3.261E-02	1.920E+02	9.366E-01
2.830E+00	-9.000E-03	-1.957E-02	1.780E+02	8.683E-01
4.000E+00	-9.000E-03	-1.957E-02	1.820E+02	8.878E-01
4.950E+00	-1.200E-02	-2.609E-02	1.920E+02	9.366E-01
5.930E+00	-5.000E-03	-1.087E-02	2.030E+02	9.902E-01
7.050E+00	-4.000E-03	-8.696E-03	2.050E+02	1.000E+00
8.040E+00	-4.000E-03	-8.696E-03	1.950E+02	9.512E-01
9.110E+00	9.000E-03	1.957E-02	1.860E+02	9.073E-01
9.980E+00	4.500E-02	9.783E-02	1.800E+02	8.780E-01
1.111E+01	6.100E-02	1.326E-01	1.820E+02	8.878E-01
1.200E+01	4.000E-02	8.696E-02	1.960E+02	9.561E-01
1.206E+01	1.100E-02	2.391E-02	1.880E+02	9.171E-01
1.260E+01	3.000E-02	6.522E-02	1.960E+02	9.561E-01
1.300E+01	0.000E+00	0.000E+00	1.660E+02	8.098E-01
1.350E+01	1.000E-02	2.174E-02	1.900E+02	9.268E-01
1.399E+01	8.100E-02	1.761E-01	1.800E+02	8.780E-01
1.400E+01	6.000E-02	1.304E-01	1.880E+02	9.171E-01
1.450E+01	1.510E-01	3.283E-01	1.940E+02	9.463E-01
1.490E+01	1.610E-01	3.500E-01	1.970E+02	9.610E-01
1.504E+01	1.460E-01	3.174E-01	1.760E+02	8.585E-01
1.555E+01	2.170E-01	4.717E-01	1.820E+02	8.878E-01
1.594E+01	1.920E-01	4.174E-01	1.970E+02	9.610E-01
1.600E+01	1.750E-01	3.804E-01	1.850E+02	9.024E-01
1.615E+01	1.270E-01	2.761E-01	1.830E+02	8.927E-01

1.650E+01	9.500E-02	2.065E-01	1.950E+02	9.512E-01
1.699E+01	6.100E-02	1.326E-01	1.830E+02	8.927E-01
1.710E+01	4.500E-02	9.783E-02	1.800E+02	8.780E-01
1.760E+01	6.600E-02	1.435E-01	1.980E+02	9.659E-01
1.800E+01	7.100E-02	1.543E-01	1.950E+02	9.512E-01
1.804E+01	8.100E-02	1.761E-01	1.760E+02	8.585E-01
1.850E+01	1.230E-01	2.674E-01	1.880E+02	9.171E-01
1.880E+01	2.280E-01	4.957E-01	1.800E+02	8.780E-01
1.904E+01	2.100E-01	4.565E-01	1.860E+02	9.073E-01
1.950E+01	2.800E-01	6.087E-01	1.950E+02	9.512E-01
2.000E+01	4.530E-01	9.848E-01	1.920E+02	9.366E-01
2.000E+01	4.350E-01	9.457E-01	1.790E+02	8.732E-01
2.060E+01	4.600E-01	1.000E+00	1.930E+02	9.415E-01
2.090E+01	2.690E-01	5.848E-01	1.920E+02	9.366E-01
2.100E+01	3.310E-01	7.196E-01	1.880E+02	9.171E-01
2.150E+01	1.050E-01	2.283E-01	1.850E+02	9.024E-01
2.190E+01	8.000E-02	1.739E-01	1.840E+02	8.976E-01
2.250E+01	7.400E-02	1.609E-01	1.900E+02	9.268E-01
2.290E+01	9.000E-02	1.957E-01	2.030E+02	9.902E-01
2.300E+01	1.400E-01	3.043E-01	1.890E+02	9.220E-01
2.340E+01	1.450E-01	3.152E-01	1.950E+02	9.512E-01
2.390E+01	2.600E-01	5.652E-01	1.880E+02	9.171E-01
2.400E+01	3.720E-01	8.087E-01	1.950E+02	9.512E-01

Table 6: First Crest Data Points

V_a (Volts)	$\propto I_c$ (Volts)	$\propto I_c$ ***Normalized***
9.11	0.009	0.019565
9.98	0.045	0.097826
11.11	0.061	0.132609
12	0.04	0.086957
12.06	0.011	0.023913
12.6	0.03	0.065217
13	0	0

Figure 7: Sigma Plot Regression for Crest 1



Interpolation:

$I_c \propto \sim(-0.0263 \pm 0.0090) * V_a^2 + (0.5747 \pm 0.1985) * V_a + (-3.0244 \pm 1.0832)$

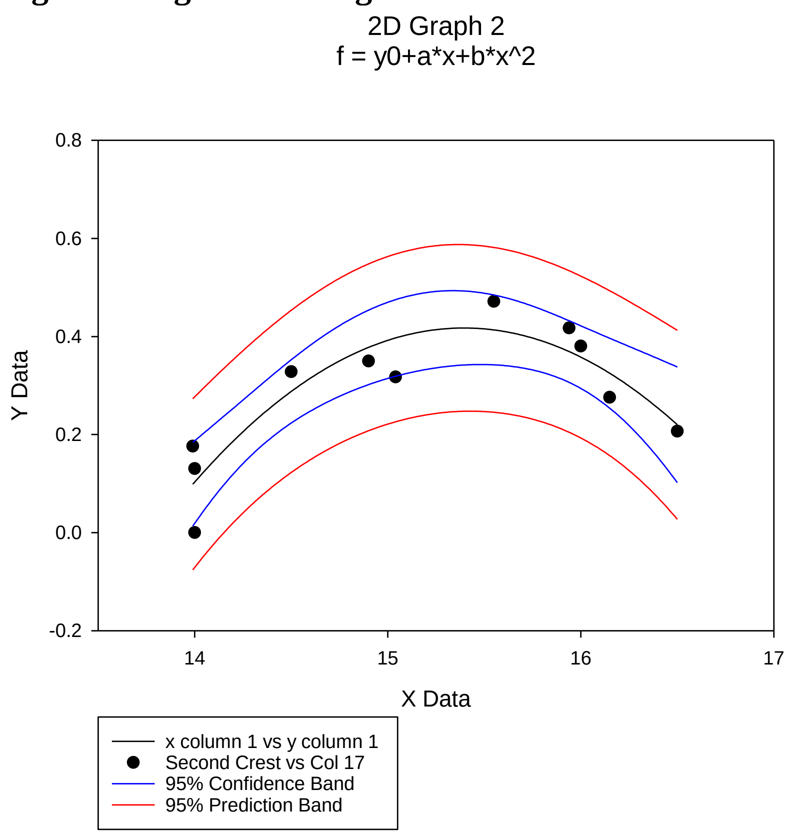
$I_c' \propto \sim(-0.0526 \pm 0.018) * V_a + (0.5747 \pm 0.1985)$

$V_{center} \;=\; 10.9 \pm 5.3$

Table 7: Second Crest Data Points

V_a (Volts)	$\propto I_c$ (Volts)	$\propto I_c$ *Normalized*
13.99	0.081	0.176087
14	0.06	0.130435
14	0	0
14.5	0.151	0.328261
14.9	0.161	0.35
15.04	0.146	0.317391
15.55	0.217	0.471739
15.94	0.192	0.417391
16	0.175	0.380435
16.15	0.127	0.276087
16.5	0.095	0.206522

Figure 8: Sigma Plot Regression for Crest 2



Interpolation:

$I_c \propto \sim(-0.1616 \pm 0.0344) * V_a^2 + (4.9766 \pm 1.0432) * V_a + (-37.8887 \pm 7.8738)$

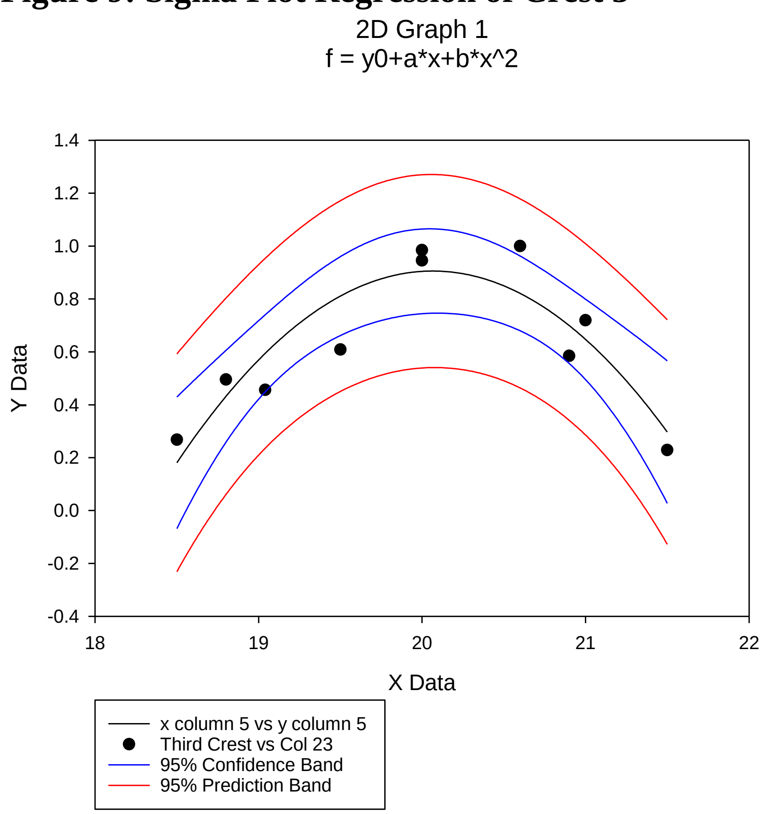
$I_c' \propto \sim(-0.3232 \pm 0.0688) * V_a + (4.9766 \pm 1.0432)$

$V_{center} = 15.40 \pm 4.60$

Table 8: Third Crest Data Points

V_a (Volts)	$\propto I_c$ (Volts)	$\propto I_c$ *Normalized*
18.50	0.123	0.267391
18.80	0.228	0.495652
19.04	0.210	0.456522
19.50	0.280	0.608696
20.00	0.453	0.984783
20.00	0.435	0.945652
20.60	0.460	1.000000
20.90	0.269	0.584783
21.00	0.331	0.719565
21.50	0.105	0.228261

Figure 9: Sigma Plot Regression of Crest 3



Interpolation:

$$I_c \propto \sim(-0.2960 \pm 0.0556) * V_a^2 + (11.8787 \pm 2.2199) * V_a + (-118.2699 \pm 22.1231)$$

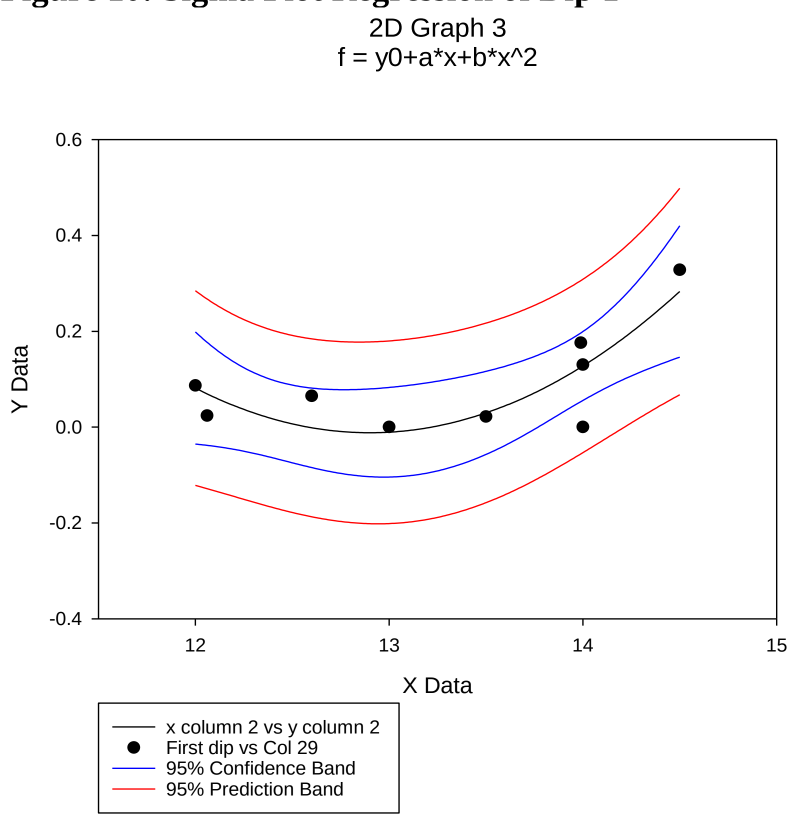
$$I_c' \propto \sim(-0.592 \pm 0.1112) * V_a + (11.8787 \pm 2.2199)$$

$$V_{center} = 20.1 \pm 5.32$$

Table 9: First Dip Data Points

V_a (Volts)	$\propto I_c$ (Volts)	$\propto I_c$ *Normalized*
12.00	0.040	0.086957
12.06	0.011	0.023913
12.60	0.030	0.065217
13.00	0.000	0.000000
13.50	0.010	0.021739
13.99	0.081	0.176087
14.00	0.060	0.130435
14.00	0.000	0.000000
14.50	0.151	0.328261

Figure 10: Sigma Plot Regression of Dip 1



Interpolation:

$I_c \propto \sim(0.1152 \pm 0.0407) * V_a^2 + (-2.9734 \pm 1.0740) * V_a + (19.1666 \pm 7.0501)$

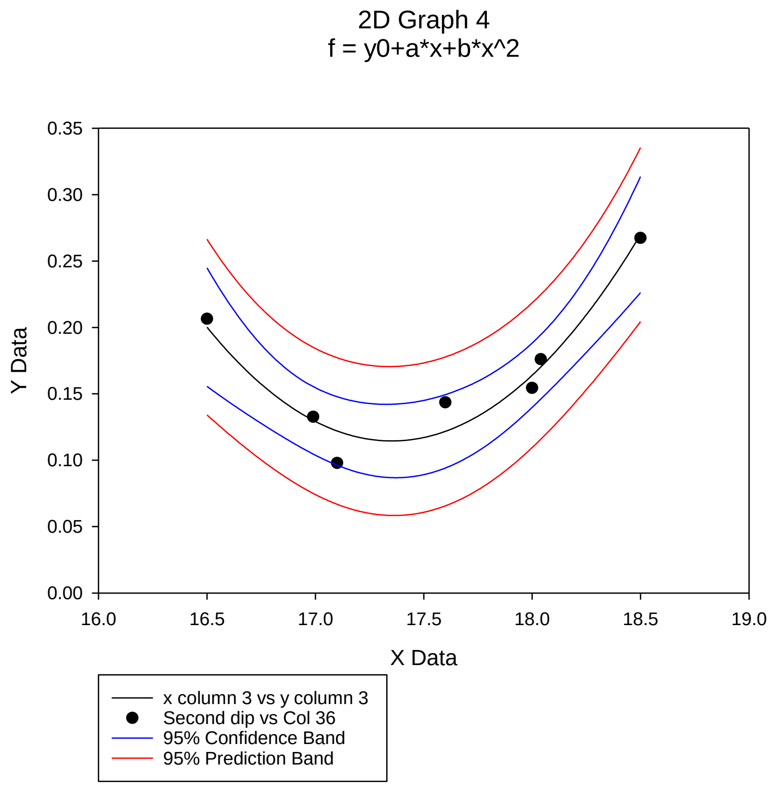
$I_c' \propto \sim(0.2304 \pm 0.0814) * V_a + (-2.9734 \pm 1.0740)$

$V_a \;=\; 12.90 \pm 6.51$

Table 10: Second Dip Data Points

V_a (Volts)	$\propto I_c$ (Volts)	$\propto I_c$ ***Normalized***
16.50	0.095	0.206522
16.99	0.061	0.132609
17.10	0.045	0.097826
17.60	0.066	0.143478
18.00	0.071	0.154348
18.04	0.081	0.176087
18.50	0.123	0.267391

Figure 11: Sigma Plot Regression for Dip 2



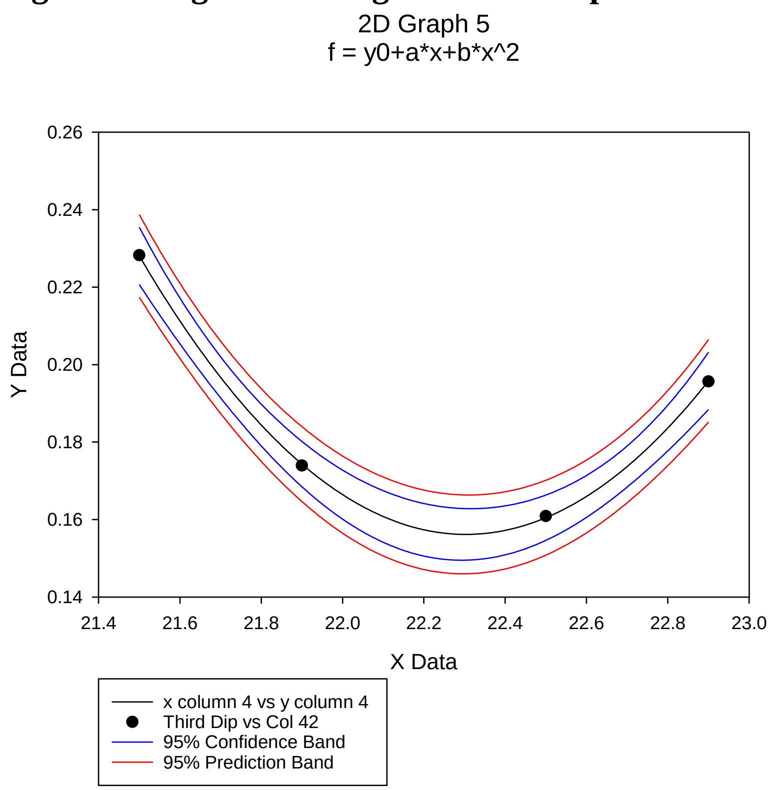
Interpolation:

$I_c \propto \sim(0.1180 \pm 0.0178) * V_a^2 + (-4.0965 \pm 0.6220) * V_a + (35.6569 \pm 5.4370)$
$I_c' \propto \sim(0.2360 \pm 0.0356) * V_a + (-4.0965 \pm 0.6220)$
$V_{center} = 17.40 \pm 3.72$

Table 11: Third Dip Data Points

V_a (Volts)	$\propto I_c$ (Volts)	$\propto I_c$ ***Normalized***
21.5	0.105	0.228261
21.9	0.08	0.173913
22.5	0.074	0.16087
22.9	0.09	0.195652

Figure 12: Sigma Plot Regression for Dip 3



Interpolation:

$I_c \propto \sim(0.1114 \pm 0.0015) * V_a^2 + (-4.9698 \pm 0.0672) * V_a + (55.5779 \pm 0.7457)$

$I_c' \propto \sim(0.2228 \pm 0.0030) * V_a + (-4.9698 \pm 0.0672)$

$V_{center} \;=\; 22.31 \pm 0.6000$

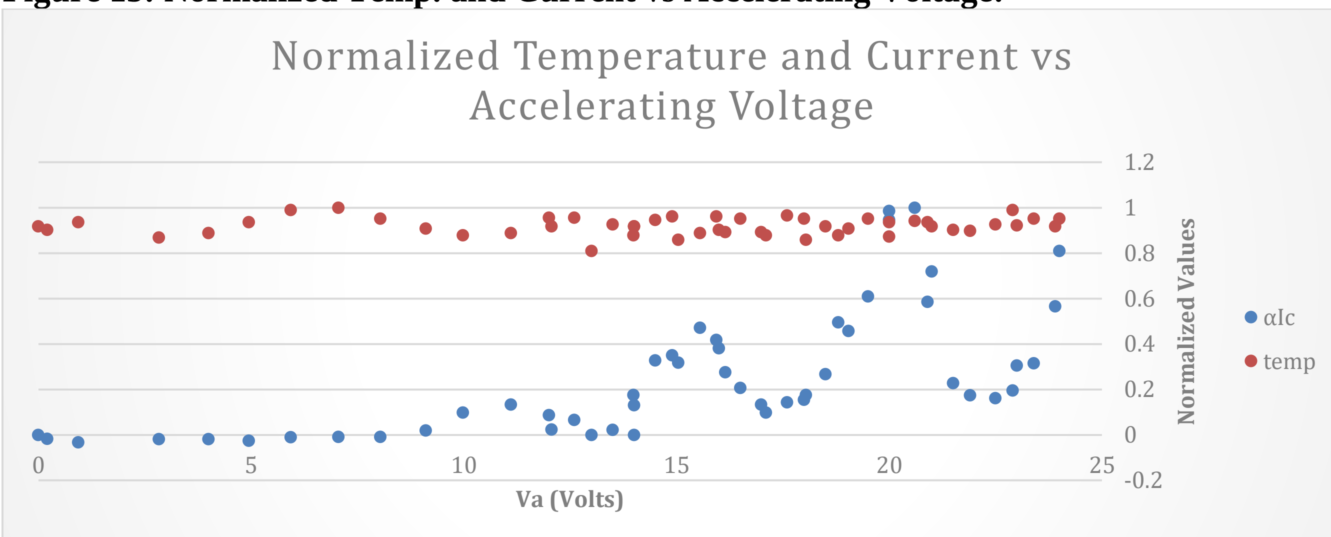
Table 13: Difference in Voltage of Peaks and Troughs

Crest (Volts)	**Uncert.**	**Δ(Volts)**	**Uncert.**	**Dip (Volts)**	**Uncert.**	**Δ(Volts)**	**Uncert.**
10.90	5.31			12.90	6.52		
15.40	4.60	4.50	7.03	17.40	3.72	4.45	7.51
20.10	5.32	4.70	7.03	22.30	0.43	4.95	3.74

Table 14: Frequency and Wavelength

	Value	Uncert.	Accepted Value	percent error (%)
Energy Difference Average (eV)	4.65	3.25	4.9	5
Spectral Frequency (Hz)	1.13E+15	7.90E+14	1.18E+15	5
Wavelength (nm)	267	186	253.70	5

Figure 15: Normalized Temp. and Current vs Accelerating Voltage:



Calculations:

Volts to Electron Volts

$$Energy(eV) = V * \frac{1eV}{V}$$
$$= 4.65V * \frac{1eV}{V}$$
$$= 4.65\ eV$$

Spectral Frequency

$$f = \frac{E}{h}$$
$$= \frac{4.65\ eV}{4.133 * 10^{-15} eV * s}$$
$$= 1.13 * 10^{15} s^{-1}$$

V center of Peaks and Dips

$$V_{center} = -\frac{a}{2 * b}$$
$$= \frac{0.0655}{2 * 0.0040} V$$
$$= 8.2\ V$$

Uncertainty of V center

$$\Delta V = \sqrt{\left(\frac{\Delta a}{a}\right)^2 + \left(\frac{\Delta b}{b}\right)^2}$$
$$= \sqrt{\left(\frac{0.0028}{-0.0655}\right)^2 + \left(\frac{0.0002}{0.0040}\right)^2}$$
$$= 0.54\ V$$

Average Uncertainty

$$\Delta Avrg = \frac{\sqrt{\sum_{i=1}^{N} \Delta V_i^2}}{N}$$
$$= \frac{\sqrt{7.03^2 + 7.03^2 + 7.51^2 + 3.74^2}}{4}$$
$$= 3.25$$

Analysis of Error:

The Franck- Hertz experiment was a success. For both Xenon and Mercury gas there was found to be discrete values of energy needed to excite the atom.

In part A of the experiment, Xenon gas, there is a very clear dip in the current around 8.2V. The apparatus was not built to proceed past the first excitation level, and thus it was impossible to calculate the excitation energy of Xenon, as there was no second peak or dip to compare with the first. It did, however, allow us to confidently confirm that only once the excitation energy of Xenon was reached would the accelerating electrons undergo inelastic collisions with the gas.

In the first section of Part B two methods of gathering data were attempted, each yielding their own results that agreed with the theoretical values. For the oscilloscope method of Part B the excitation energy was found to be at multiples of 5.0±1.0 eV, where the theoretical value is 4.9eV. This led to a wavelength of 247.98±12.40 nm for its emitted light, where theoretically it is 253.7nm. This represents a 2% percent error from the theoretical values.

There was substantial human error when reading the oscilloscope, seeing as it was difficult to properly estimate where along the x-axis lay the maxima and minima. This is taken into account in our uncertainties.

In section II of part B we used multi-meters to record discrete values from the oven. During this section we found the excitation energy to be multiples of 4.65±12.10 eV, and the wavelength emitted to be 266.65±693.28 nm. The huge uncertainties in these values comes from fitting parabolic curves to the data in order to interpolate where the location of the maxima and minima of the blue data in Figure 15. The results, though imprecise, were quite accurate, with an error of only 5% from the theoretical values.

For both section I and II of part B there were several sources of error. Firstly, it was very difficult to have a constant temperature in the oven. Although this was carefully observed and adjusted accordingly (see the orange data in Graph 2), the changes could have altered the results of this experiment, for temperature inside the oven and the recorded current are directly correlated. Another potential source of error was keeping the accelerating voltage steady. We had to zero the accelerating voltage repeatedly, especially when the oven was heating or cooling. Another source could have been the resistance in the wires used. This experiment could have been improved if it was conducted in a perfect oven in order to maintain constant heat, with apparatus that also allowed us to maintain a steady accelerating voltage, and if all connection throughout the apparatus were perfect.

Discussion:

The goal of this experiment was to show the discrete quantized states of two different gases using both the Franck Hertz board and the Franck Hertz oven. In the two variations of this experiment we were able to accelerate electron through a gas and observe how the different amounts of kinetic energy of the electron affected the collisions between the electron and the gas atoms. This allowed us to record the excitation energies of the gases and from this calculate the wavelength of the light emitted when the atom was de-excited.

In the first experiment we used the Franck Hertz board to record values of the first excitation of Xenon. From this portion of the experiment we were only able to find the moment in which the electrons in the Xenon atoms had enough energy to undergo one level of ionization. Which was a success for when the collisions in our experiment went from elastic to inelastic we were able to find an energy of 8.2V.

The second portion of the experiment, involving the mercury oven, consisted in analysing the different discrete quantized levels of the mercury atom. We were successful in finding an accurate result for both sections of part B, although the results were not precise. For the values in this part of the experiment were, 5.0±1.0 eV and 4.65±12.10 eV which agreed, with in reason, with the theoretical value of this experiment, 4.9eV. And resulted in wavelengths of 247.98±12.40 nm and 266.65±693.28 nm. These results were accepted values, for they lay with in the predicted spectrum, ultraviolet.

To improve the uncertainty of these results more accurate apparatus could have been used for much of the uncertainty in this lab came from the fluctuation in the heat of the oven and from the lack of precision in the accelerating voltage. A way to improve our results would have been to repeat this experiment multiple times, thus providing us with more data points and from this we would have resulted in a graph of data that contained less scattering and more accuracy.

Conclusion:

In this lab we were able to demonstrate that energy is quantized in atomic interactions. For in the Franck-Hertz board experiment we were successful in finding the first excitation of the Xenon gas, which was 8.2V. The second part of the experiment using the Mercury filled vacuum allowed us to confirm more of the theory behind the Franck-Hertz experiment for it allowed us to find an accurate value for the discrete quantized levels of Mercury, which in turn allowed us to confirm Bohr's theory of an atom. Section I of part B had a result of the energy level to be 5.0±1.0 eV, and through calculations led us to an emitted wavelength of 247.98±12.40 nm. These results have a percent error of only 2% from their theoretical values.

In section II we found the discrete quantized level to be at 4.65 ± 12.1 eV, with a wavelength of 266.65±693.28 nm. When comparing this to the theoretical value of 4.9 eV and 267nm we obtain an experimental error of 5%. This portion of the experiment had a higher uncertainty for the results were taken from, Figure 15: Normalized Temp. and Current vs. Accelerating Voltage, which had lots of scattering and not a clear peak to gather the results from.

Based on these results we conclude the experiment to be a success and confirm that both Mercury and Xenon have discrete quantized energies, as well as how the energy loss in an atom directly correlates to the wavelength emitted.