The Lab! Procedure/Planning/Notes

-1.1k volts 4.12 mA 363 torr from 348 torr

turning down to 3mA doesn't discharge but plasma is dimmer.

As I goes up, plasma gets brighter

5.25 mA -1200V ~~350~~ torr (moved to 340 and finally settled)

run1 is with default parameters

run2 is with increment 1 volt (vstep)

There's a stretch with no plasma.

Pressure seems to change when we're doing runs - due to changed state of matter?

This Friday, let's try with P = ~~500~~ mtorr 550
Next Friday, let's try with P = ~~200~~ mtorr 270

We should try with different voltages as well.

The zero-point for I at 340 torr was between -21 and -20. We would like to find the zero point, so we should zoom in on this by having a step <1. We realize this may change with our pressure. We will also take data over a lesser range for this part.

I would also like to take data over wider ranges of V. Because of the cap on I (caused by the equipment's capacity), we may have to up our range gradually if we can't find ~~out~~ the resistance (and should not go to the theoretical maximum because there could be resistance from other parts of the setup, even if it should be small.

Our resistor is 75 [kOhm]. So assuming no other resistance,
$I = \frac{V}{75 \cdot 10^3 \, [\text{ohm}]} = \boxed{\frac{V}{75} \cdot 10^{-3} \, [\Omega^{-1}]}$. This should cover our voltage ranges, but we should check our allowed I during the Lab today.

~~Week 2 pressure: 590 [mtorr] ±10 Minimum Voltage: 4.67 [mA] ±2, 1300 [V]~~

Week 2 pressure: 585 [mtorr] ±5 | Voltage: 1300 [V] Current: 4.42 [mA]

Our plot at the upper end of the allowed pressure range is much more flat than the mid-range are.

At our $P=565$ [mtorr], we are far from our floating potential.

Kris has told us that as long as $I \leq 8$ [mA] our pressure can be whatever we want. So we are going to get it as low as we can.

We got it down to $P = \cancel{\ }\ 154$ [mTorr]. Neat! Alright

At this point we could not form a plasma no matter what voltage we used, so the required voltage is too high.

~~We have P back up to 557 [mTorr]. We are going to take some data at varying voltages to compare them.~~
~~It broke at 1300 [V]~~ Then it stopped so let's try again

$P=592$ [mTorr], $V=1400$ [V] $I=5.41$ [mA]

$I = e^{-e^-(V_b - V_{bias})/kT_e}$

$a = \frac{e^-}{kT_e}$ $b = \frac{-e^- V_b}{kT_e}$

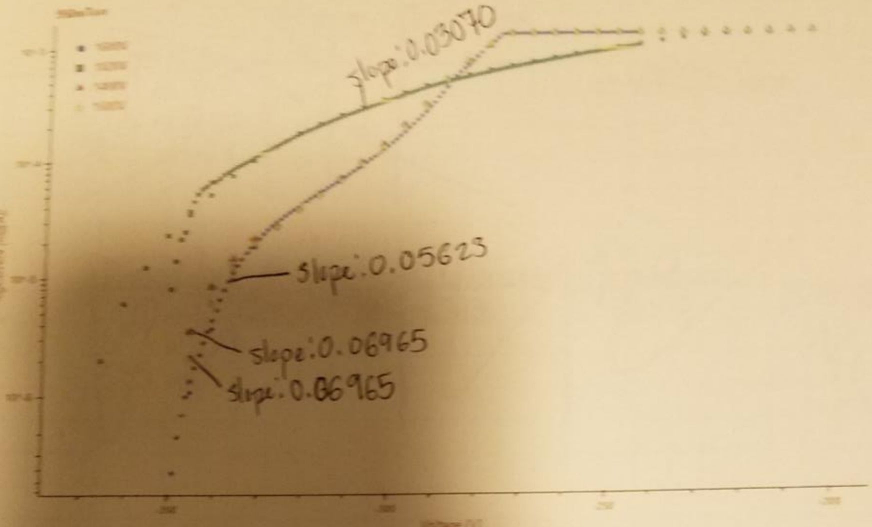
using linear fit

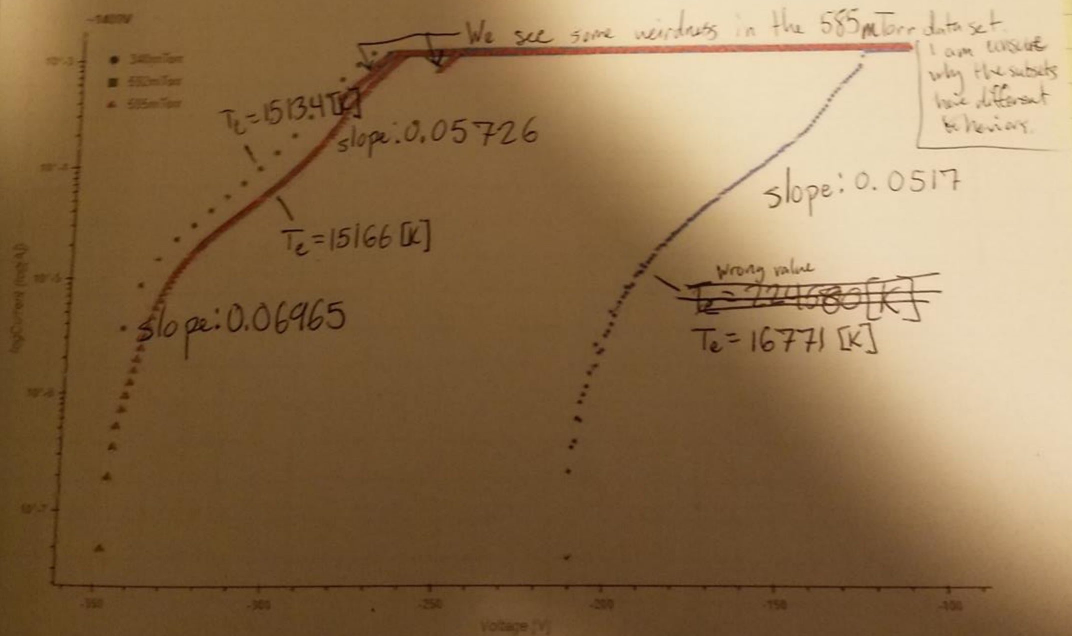
$T_e = \cancel{\ } \frac{e^-}{ka}$

It should be noted that this lab uses $|V_{bias}|$, as all our voltages are negative.

Lab partner: Idris Koran

Langmuir Data





Given slopes are for electron-dominated regions only, which are toward the upper regions of the curves.

T_e = Expected Temperature, T_c = Calculated Temperature.

22 Langmuir Calculation Code

Here, I said temperature when I meant slopes, I believe I have fixed it but there may still be errors.

The Langmuir probe is a pressurized tube which runs a sweeping potential through a plasma. We controlled this sweeping potential and recorded current over the sweeping potential using code written in python. Python was used for data analysis as well. By comparing slopes for electron-dominated currents under various pressures at similar base voltages, we found that our temperature — as we would expect — ~~in~~ de creased with increasing pressure. By comparing slopes for electron-dominated currents at various base voltages at the same pressure, we found that the shape of the current function was much more pronounced at higher magnitude base voltages, and that because of the more curved shape, temperature dropped as base voltage ~~de~~ in creased.

Data Analysis

Langmuir Probe

14th September, 2018

Kitty Harris and Idriss Kacou

```
In [1]: import pandas as pd
        import scipy
        from scipy import optimize
        import scipy.constants
        import numpy as np
        import matplotlib.pyplot as plt
        %matplotlib inline
        from bokeh.plotting import figure, output_notebook, show

In [2]: [illegible]
        df = pd.read_csv([illegible])
        [illegible] = df.iloc[:,1].values
        y = df.iloc[:,1].values
```

```
In [88]: #I took this from Experimental Setup.
         #It has been modified it slightly to fit the defined variables.

         # Specifying that we want the plot to be displayed within the notebook
         output_notebook(hide_banner=True)

         # create a new plot with a title and axis labels.
         #DON'T FORGET TO CHANGE THE TITLE IF YOU CHANGED THE DATA
         p = figure(title="592mTorr 1020V Master Dataset", x_axis_label='Voltage (V)', y_axis_l

         # specify the data to plot and define the line type - here we will use a circle for tl
         p.circle(x, y, fill_color="white", size=8)

         # show the results
         show(p)
```



```
In [33]: #Now we want the logY plot.
         #DON'T FORGET TO CHANGE THE TITLE IF YOU CHANGED THE DATA
         p = figure(title="592mTorr 1020V Master Dataset logY", x_axis_label='Voltage [V]', y_a

         # specify the data to plot and define the line type - here we will use a circle for tl
         p.circle(x, y, fill_color="white", size=8)

         # show the results
         show(p)
```

```
In [24]: #Now we want to show multiple data on the same plot.
         #First we need to define more data.
         af = pd.read_csv("340mTorr Data Master.csv")
         bf = pd.read_csv("Data/592mTorr/KHIK592mtorr1400V.csv")
         cf = pd.read_csv("565mtorr Data Master.csv")
         #df = pd.read_csv("Data/592mTorr/KHIK592mtorr1500V.csv")
         #copy and paste this, changing the first letter until you have as many as you need.
         #Now we define X and Y
         xa=af.iloc[:,0].values
         ya=af.iloc[:,1].values
         xb=bf.iloc[:,0].values
         yb=bf.iloc[:,1].values
         xc=cf.iloc[:,0].values
         yc=cf.iloc[:,1].values
         #xd=df.iloc[:,0].values
         #yd=df.iloc[:,1].values
```


9/25/2018, 12:01 AM

Dataset	Expected Temperature (K)	Calculated Temperature (K)
592mTorr (1600V)	15134	206376
592mTorr (1500V)	15134	166612
592mTorr (1400V)	15134	166612
592mTorr (1020V)	15134	377997
585mTorr (1400V)	15166	202664
340mTorr (1400V)	16771	224459

Expected Temperature is calculated for a given pressure and gas (N^2, the closest simple analog for air) is independent of base voltage, using the prelab's formulae:

cpRterm = 16.27+2*math.log(c*p*R)

Where c and R are constant for the gas and p is our pressure,

etempRatioGuess = cpRterm

fvalue = etempRatio-0.5*math.log(etempRatio)-cpRterm

etempRatio=opt.fsolve(etempfunc,etempRatioGuess,args=(cpRterm))

etemp=Vi/etempRatio

And calculated temperature is measured as

$$m = e/kT$$
$$T = e/mk$$