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```
clear all
close all
clc

cd code
```

Introduction

The purpose of assignment 1 was to modeling the carriers as a population of electrons in an N-type Si semiconductor crystal.

Part 1 Introduction

For part 1 of the assignment the initial velocity of the electrons was set to the thermal velocity moving in a random direction. The x direction used a periodic boundary condition and the y direction used a specular reflection boundary condition. First the thermal velocity and mean free path where calculated using parameters given in the assignment instructions. Next the simulation script was run which creates a 2-D plot of particle trajectories and temperature plot over time.

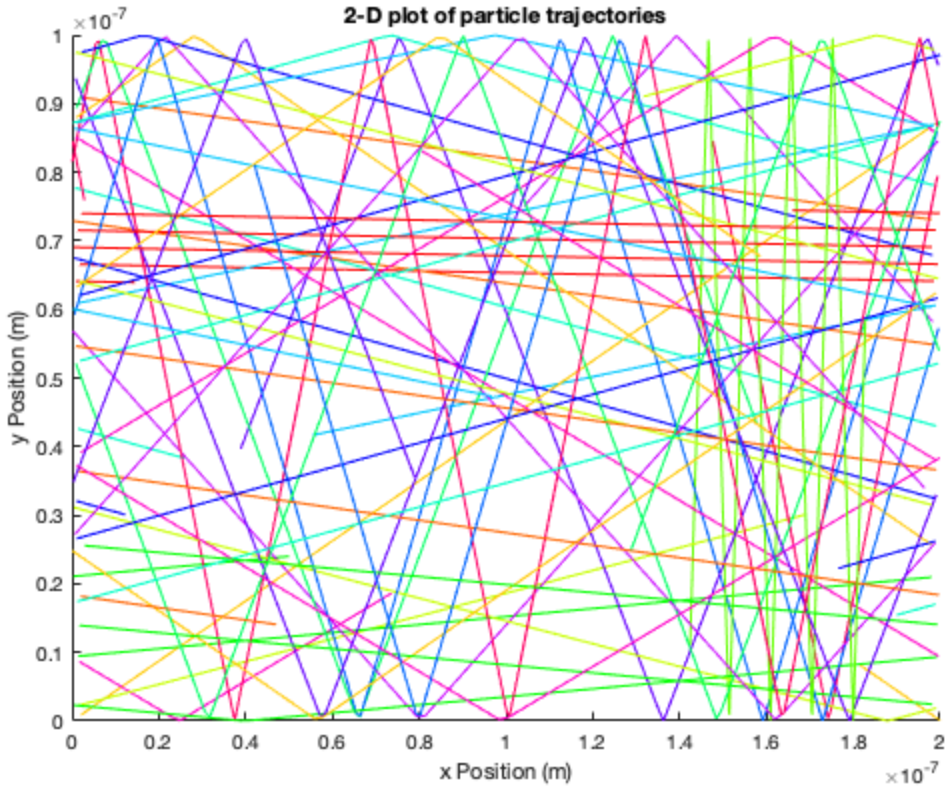
Part 1 Figures and Command Line Outputs

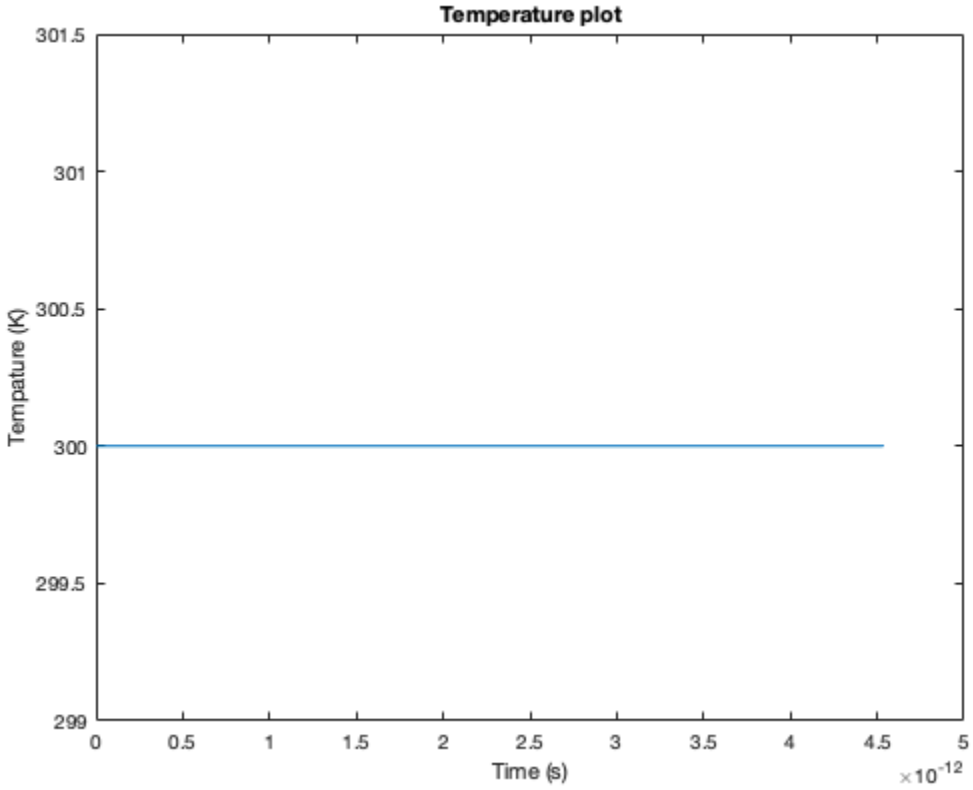
```
cd part_1_final

part1

cd ..
```

```
The calculated thermal velocity is 132212.04 m/s
The calculated mean free path is 3.7395e-08 m
```


2-D plot of particle trajectories
×10^-7
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
y Position (m)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
x Position (m)
×10^-7


Temperature plot
301.5
301
300.5
300
299.5
299
Tempature (K)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (s)
×10^-12

Part 1 Conclusion

The results of the part 1 are as I expected. The electron trajectories match the intended x and y boundary conditions. The temperature plot shows a constant temperature of 300 K, which makes sense given that the velocity of the electrons was set to the thermal velocity moving in a random direction. The thermal velocity was calculated to be 132212.04 m/s. The mean free path was calculated to be 3.7395e-08 m.

Part 2 Introduction

For part 2 of the assignment I started by assigning a random velocity to each of the particles at the start using a Maxwell-Boltzmann distribution. Next I added scattering of the electrons to my model using an exponential scattering probability. I then plotted average temperature over time and measured the mean free path and mean time between collisions in order to verify my model. Lastly I created a histogram of electron speeds and a 2-D plot of particle trajectories.

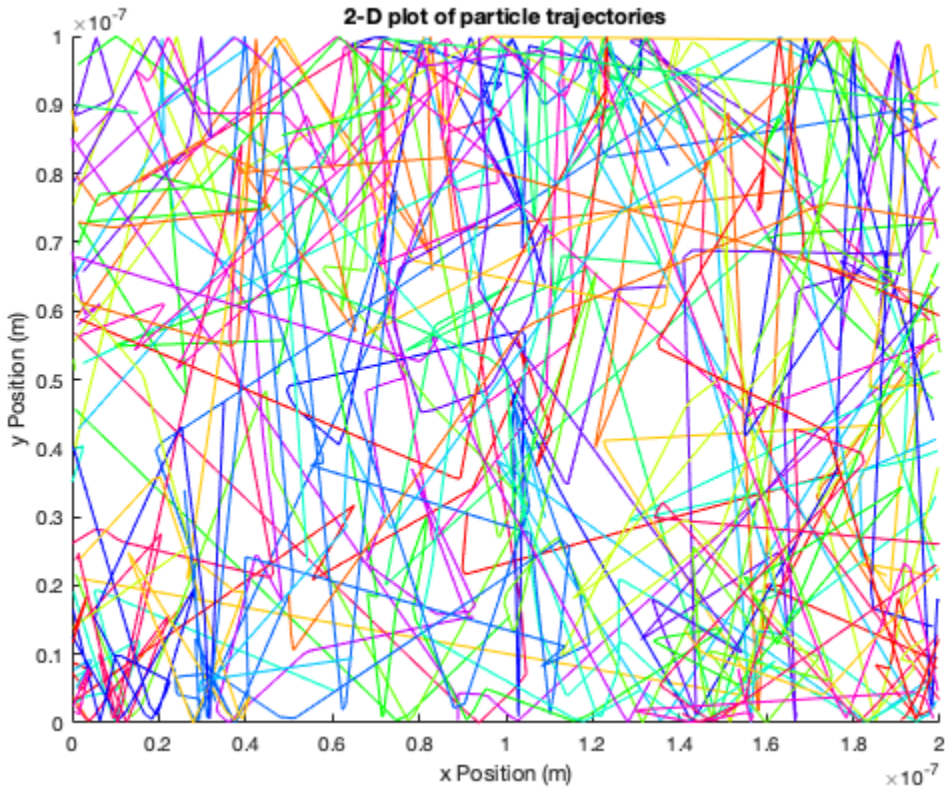
Part 2 Figures and Command Line Outputs

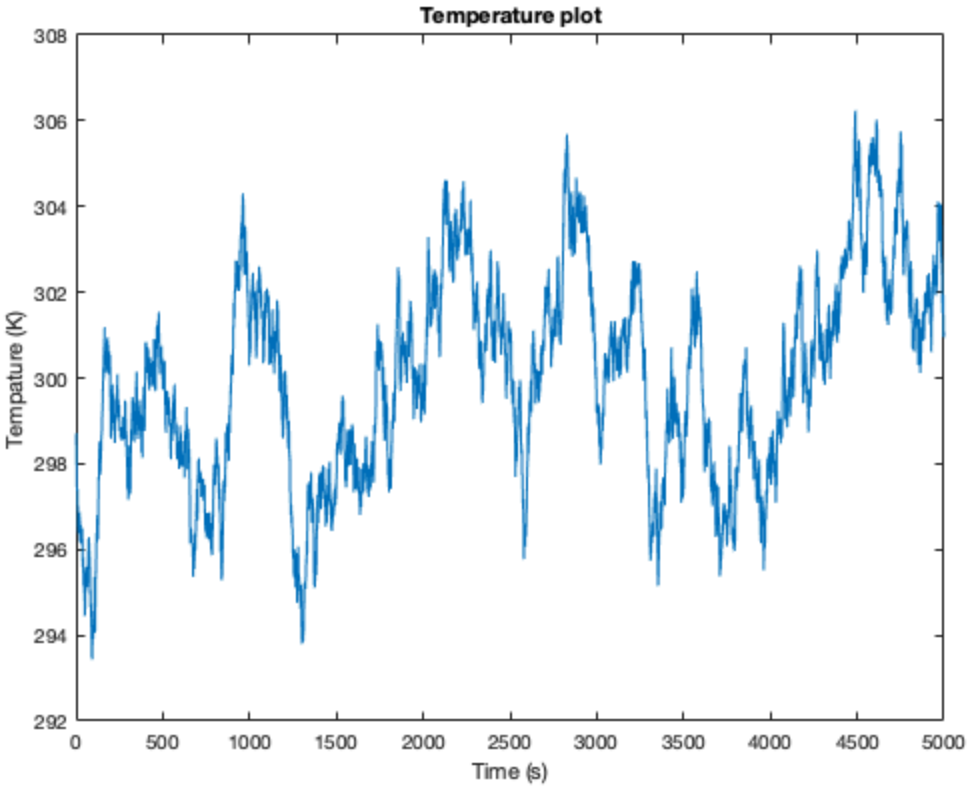
```
cd part_2_final
```

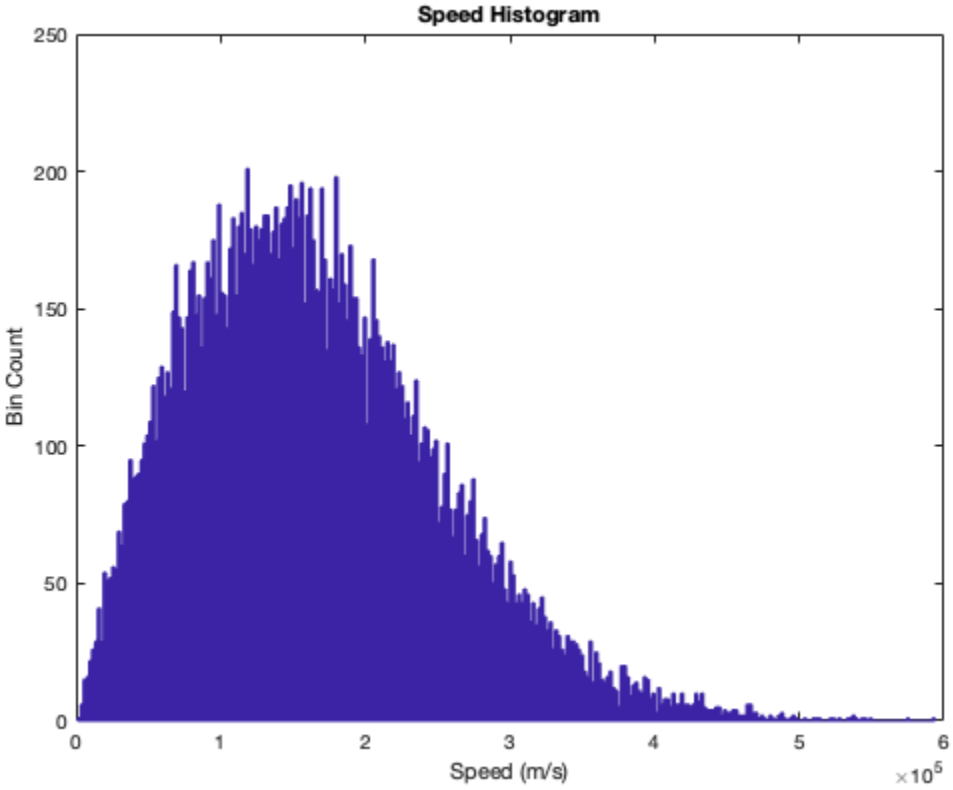
```
part2
```

```
cd ..
```

```
The measured mean time between collision is 2.0079e-13 s
The measured Mean Free Path is 3.3287e-08 m
```




Temperature plot
Tempature (K)
Time (s)
308
306
304
302
300
298
296
294
292
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Speed Histogram
Bin Count
Speed (m/s)
×10^5
250
200
150
100
50
0
0
1
2
3
4
5
6

Part 2 Conclusion

The results of part 2 are as expected. When looking at the speed histogramthe distribution appears to be Maxwell-Boltzmann, which is the speed distribution I was trying to achieve. From the 2-D plot of particle trajectories, scattering appears to work. The measured mean free path was about 3.3 e-08 m. The calculated mean free path from part 1 was 3.7395e-08 m, which is close to the measured mean free path. The measured mean time between collisions was about 0.2 e-13 s, which is exactly the same as the mean time between collisions given in part 1. The average temperature over time fluctuated around 300 K, which is as expected because the electrons where constantly scattering at velocities determined by a Maxwell-Boltzmann distribution.

Part 3 Introduction

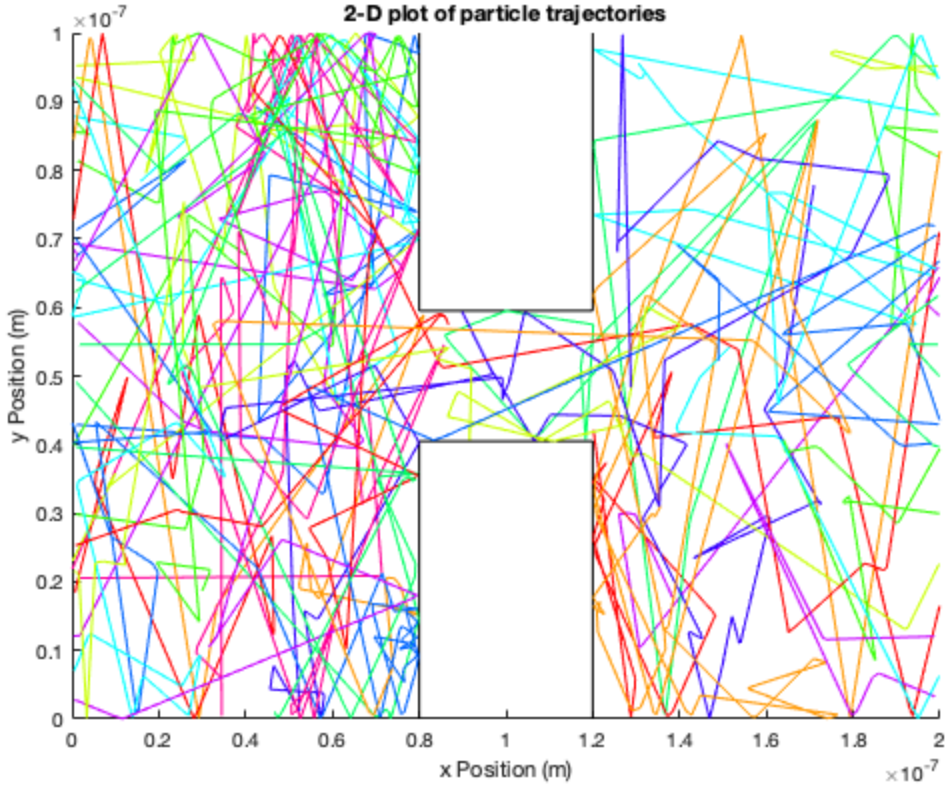
For part 3 of the assignment I started by creating 2 boxes, which together created a bottleneck. The top box had a diffusive boundary and the bottom box had a specular boundary. Once the boxes where in place three figures where created. The first figure was a 2-D plot of particle trajectories. The next plot was an electron density map for the final electron positions. The last plot was a temperature map, which displays the average temperature in each region.

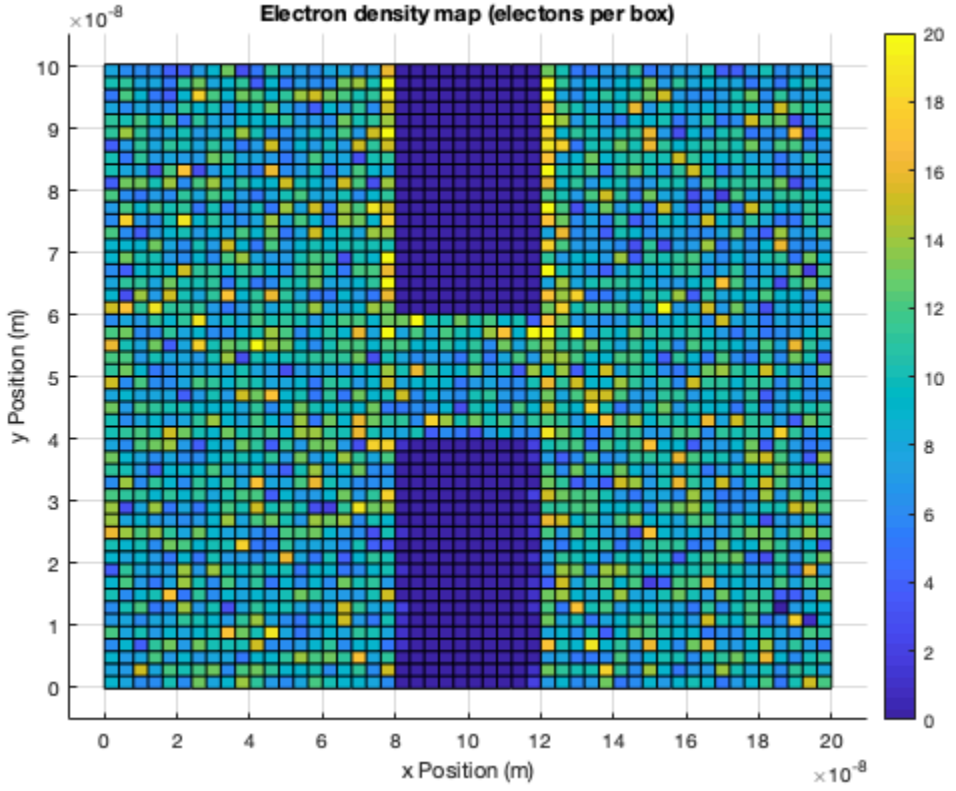
Part 3 Figures

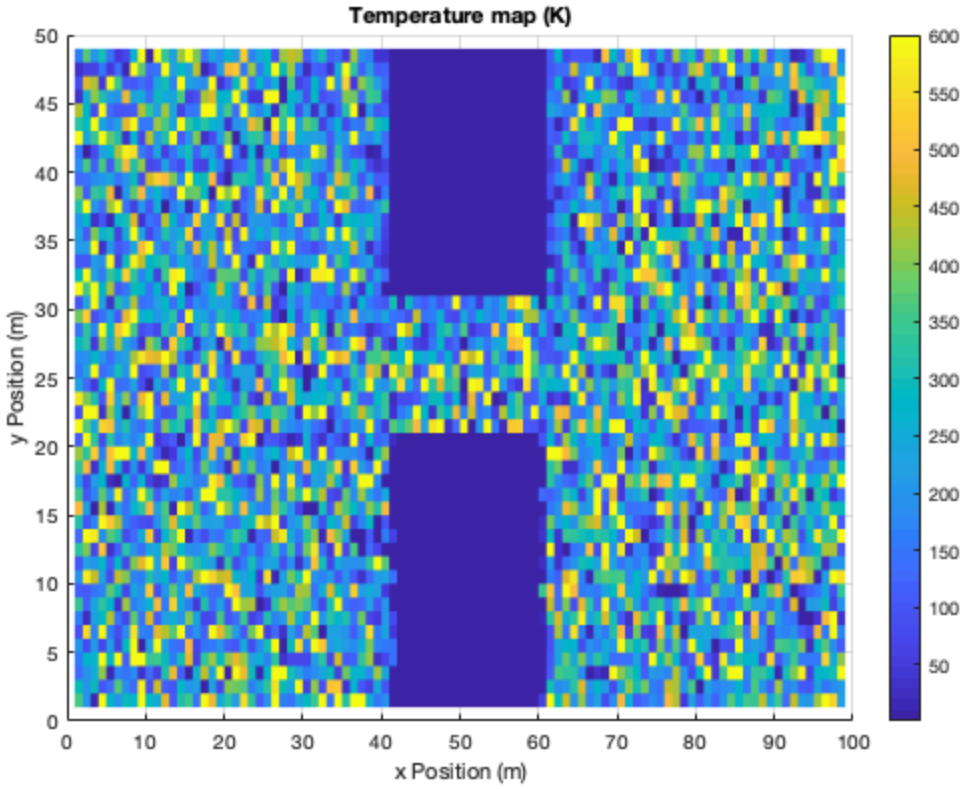
```
cd part_3_final

part3

cd ..
```


2-D plot of particle trajectories
×10^-7
y Position (m)
x Position (m)
×10^-7


Electron density map (electons per box)
×10^-8
y Position (m)
x Position (m)
×10^-8



Part 3 Conclusion

The results of part 3 where as expected. When looking at the 2-D plot of particle trajectories the particles bounce off the boxes correctly depending on the type of box. For the temperature map, the final temperature was uniformly distributed everywhere that a box was not present except close to the diffusive boundary where the average temperature was less. The average temperature was less near the diffuse boundary because some electrons colliding with the diffuse boundary lost energy and therefore remained close to the boundary. From observing the electron density map for the final electron positions, the electrons were uniformly distributed everywhere a box was not present except where close to the a diffusive boundary. The electron density was larger near the diffuse boundary because some electrons that collided with the diffuse boundary lost energy and therefore remained close to the boundary.

Conclusion

Overall Assignment 1 was a success. I was able to complete every objective and my results matched my expectation.

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