Monte-Carlo/Finite Difference Method

Author:
Julie-Anne Chaine 101104568

Assignment 3
ELEC 4700 A
A2 11:30-1:30pm
20 March 2022

1.0 Monte-Carlo with Electric Field

a) If we assume a voltage of 0.1V on the left side then the electric field will equal the potential divided by the width of the area.

$$E = \frac{0.1\,V - 0\,V}{200 * 10^{-9}\,m} = 0.5\,MV/m$$

b) Calculating force from the electric field:

$$F = E * q_e = 80.1\,fN$$

c) From the force, we can calculate the acceleration:

$$a = \frac{F}{0.26 * m_0} = 3.382 * 10^{17}\frac{m}{s}$$

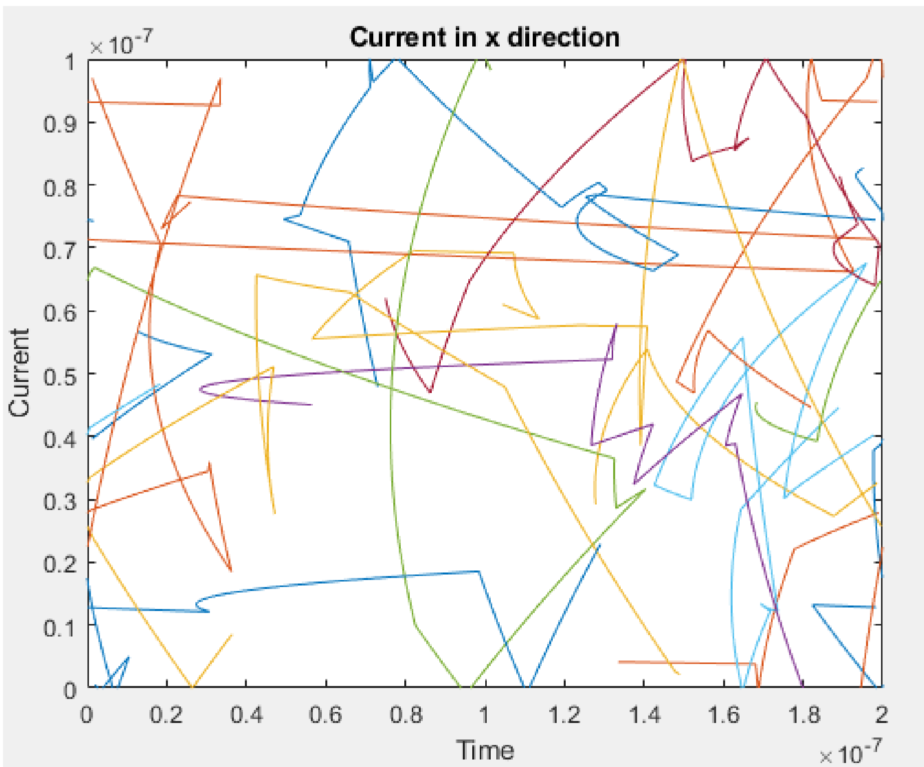

Figure 1: Particle Trajectories with Electric Field for 200 time steps

d) To calculate current:

$$J = q_e * E_{concentration} * V_{avg} * L$$

We can see that the curve will climb up as time progresses due to the acceleration however, we do see a plateau due to the scattering that halts the growing acceleration. If there was no scattering, then the particles would continuously speed up and the curve would not flatten.

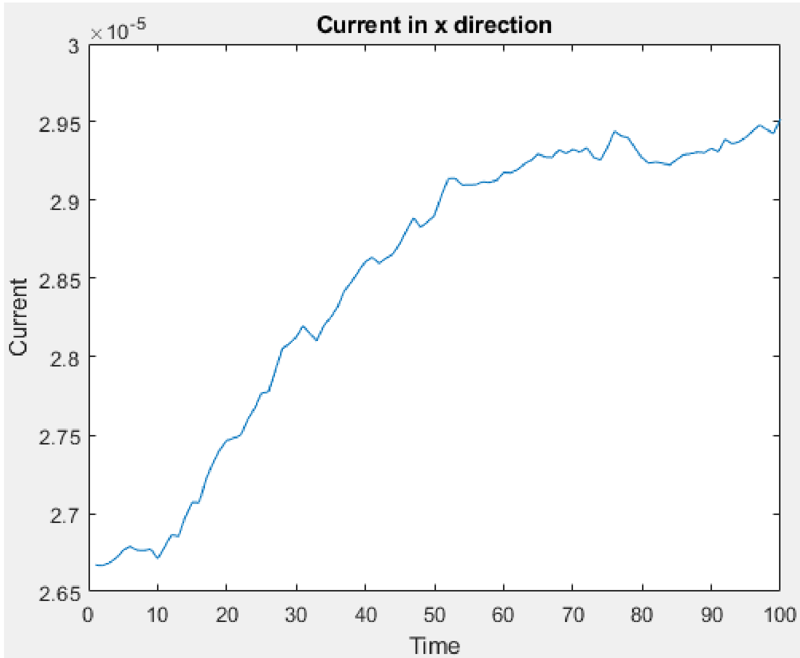

Figure 2: Current vs Time

e)

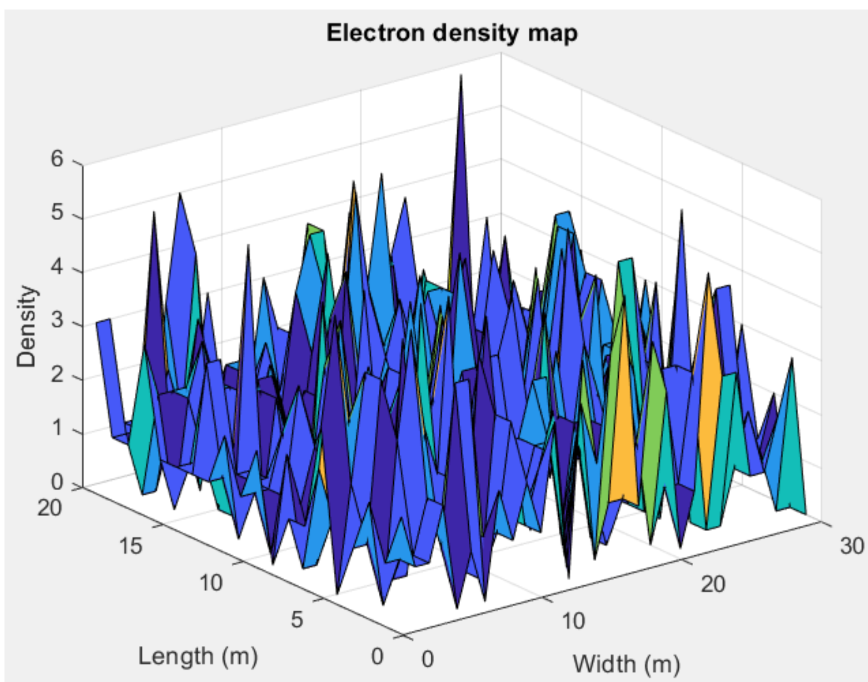

Figure 3: Electron Density Map

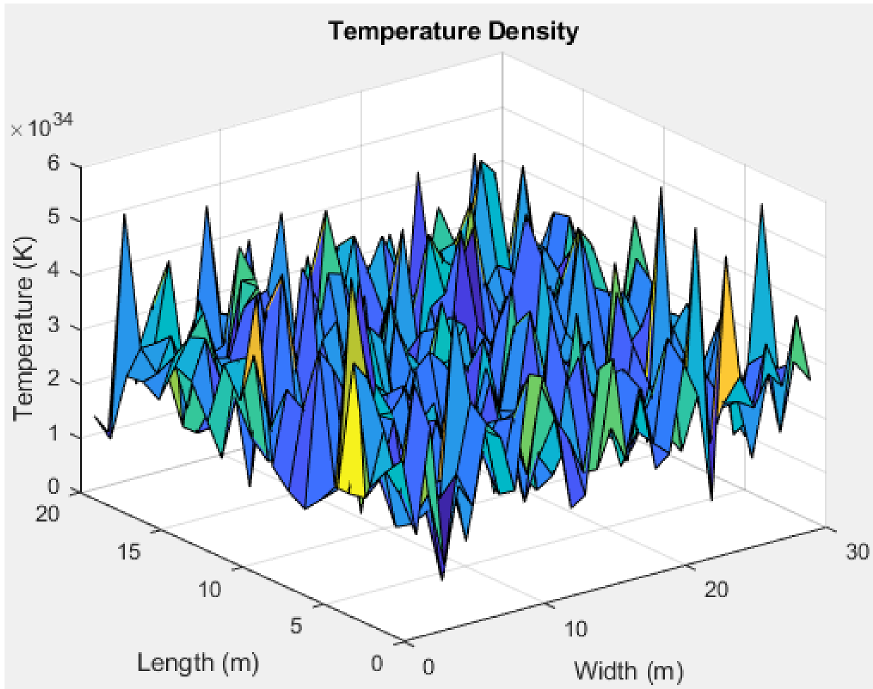

Figure 4: Temperature Map without Bottleneck

2.0 Monte-Carlo and Finite Difference Method

a.

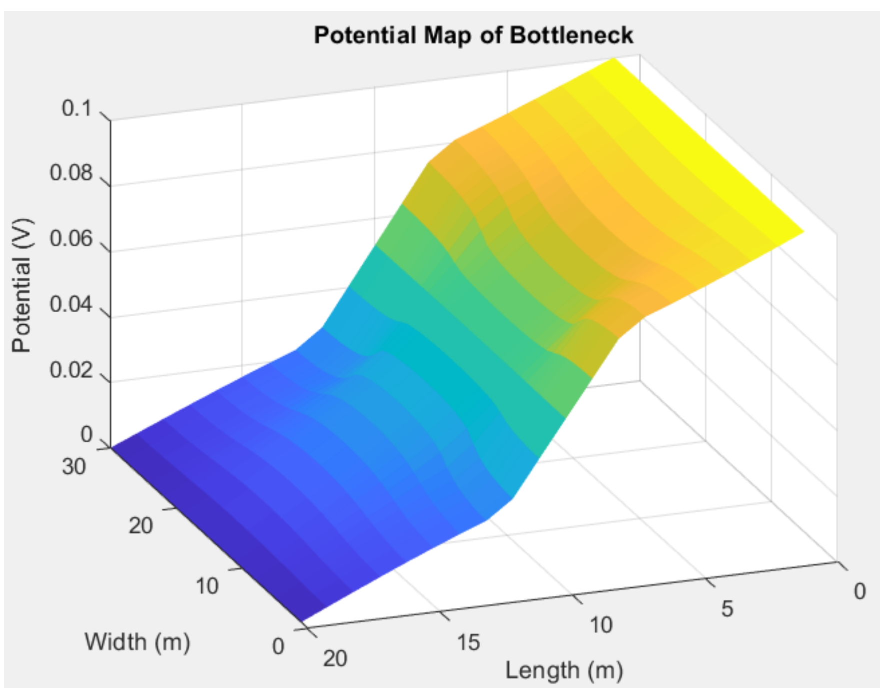

Figure 5: Potential Surface Plot

b.

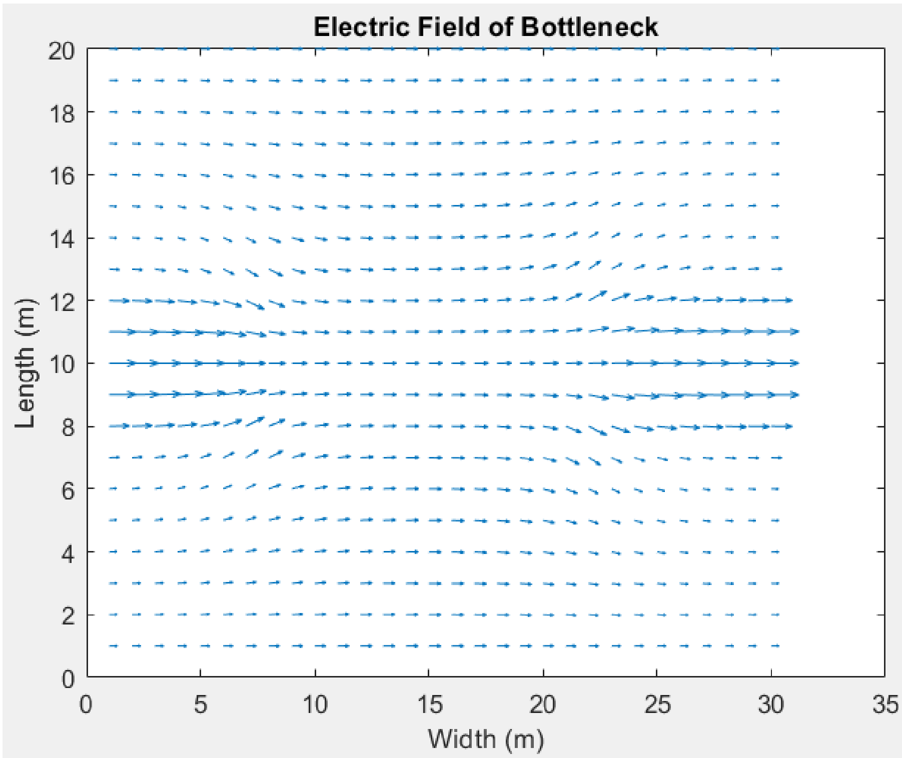

Figure 6: Electric Field Plot Calculated from Potential

c.

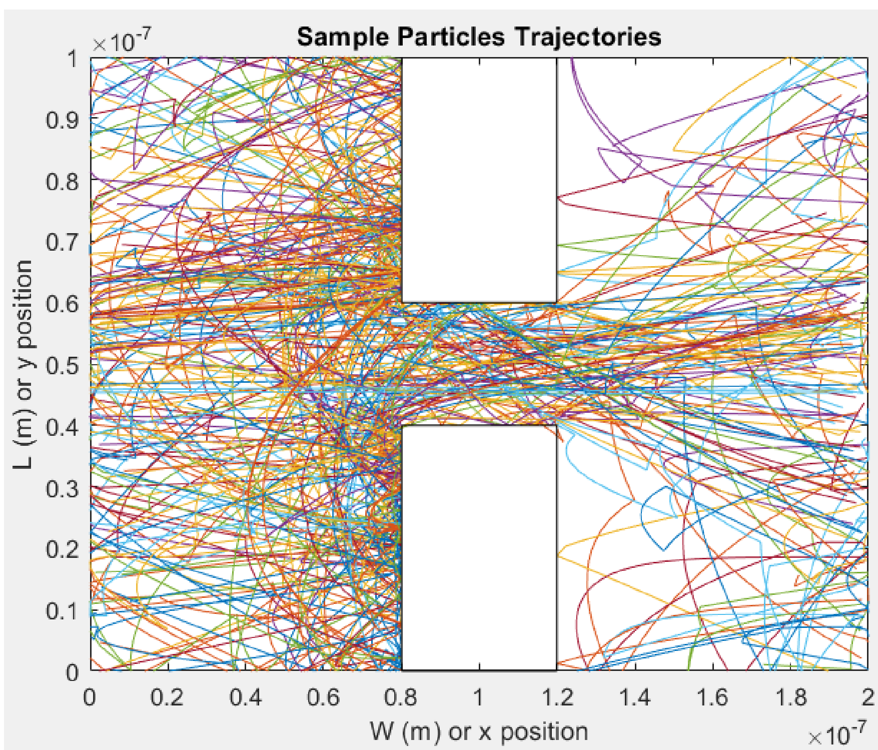

Figure 7: Particle Trajectories with Bottleneck

3.0 Device Investigation

A.

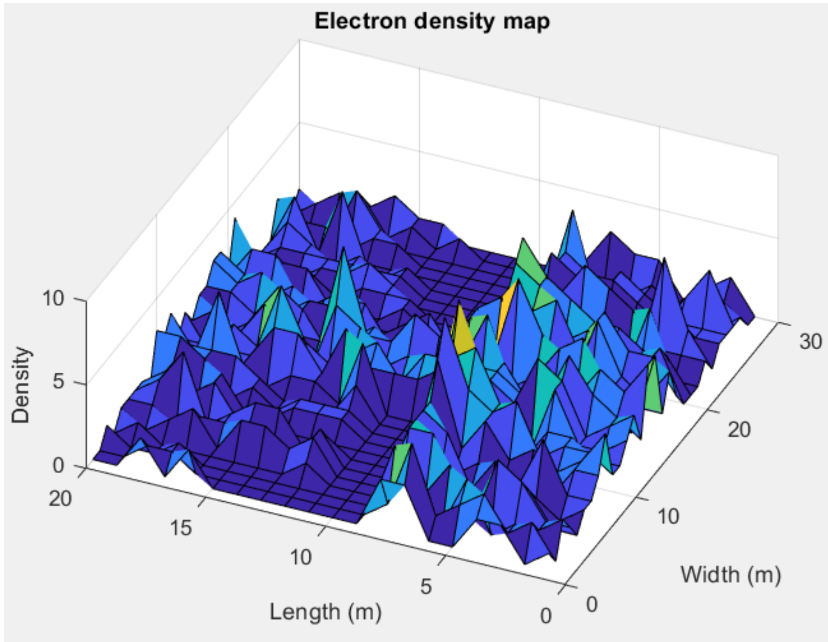

Figure 8: Electron Density Map for the Coupled Simulation

Comparing to figure 3, this plot is a lot less uniform, and we can clearly see the bottleneck form between the boxes. We can also see that the right side is denser which is expected as the particles are pulled to the right by the electric field.

B.

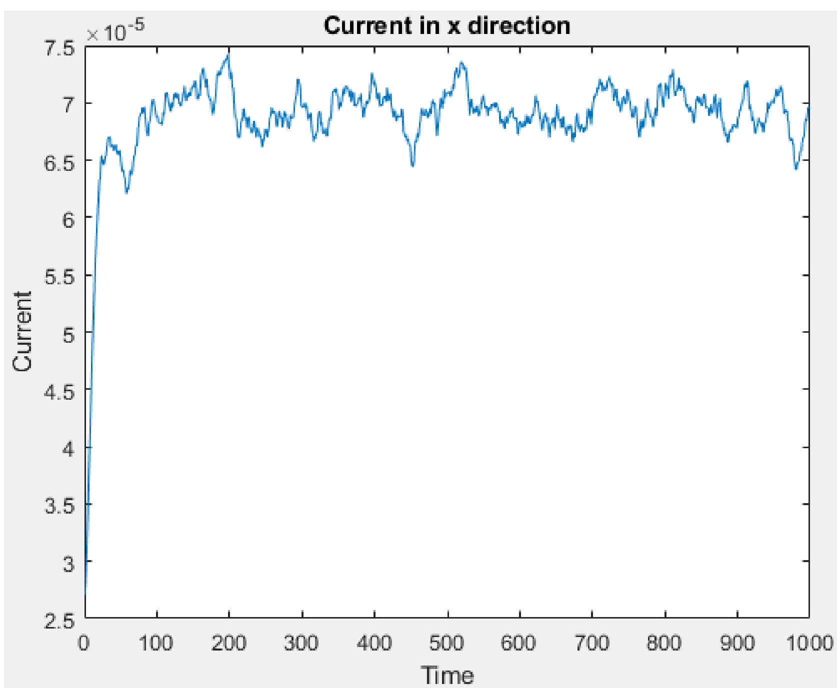

Figure 9: Current vs Bottleneck Width for a 0.2e-7 m Gap

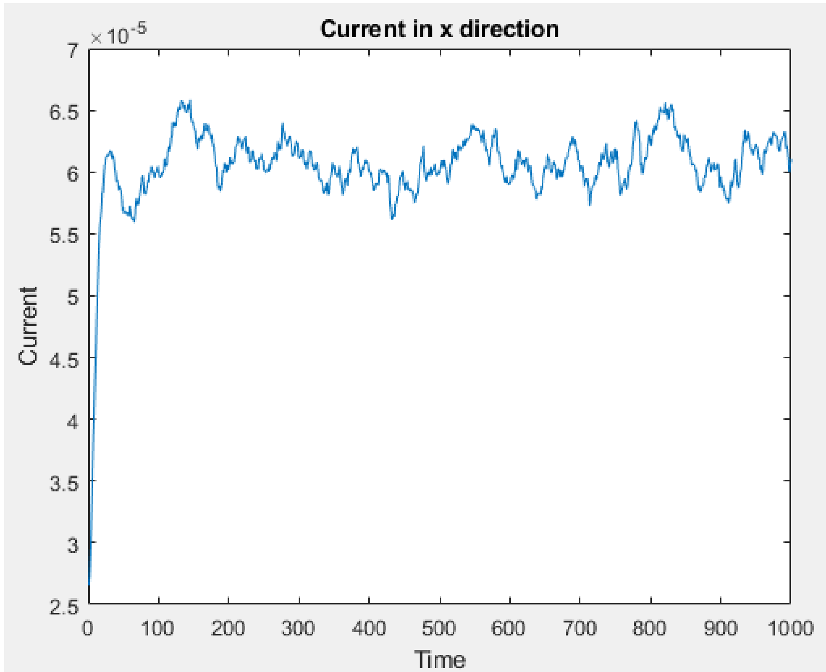

Figure 10: Current vs Bottleneck Width for a 0.1e-7 m Gap

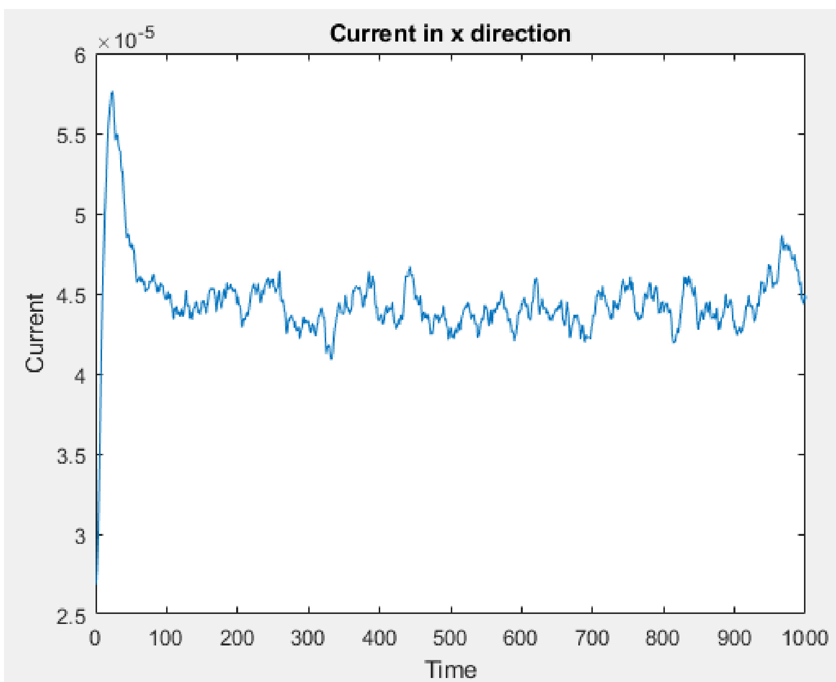

Figure 11: Current vs Bottleneck Width for a 0.6e-7 m Gap

From the above three plots, we can see that the current plateaus earlier when the gap is narrower but we see the biggest drop when the gap is at the larger end.

C. To make the simulation more accurate, we could use electric fields that aren't constant. We would also not assume perfect energy conservation when a particle hits a boundary.