ELEC 4700

Assignment 1

Monte-Carlo Modeling of Electron Transport

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Part 1: Electron Modelling

First part is modelling electron particles inside silicon, with an effective mass of $0.26m_0$. The Dimensions of the modelled area are 200 nm x 100 nm.

Assuming that T = 300K, Thermal Velocity is equal to 1.87 x 10^5 m/s using MATLAB code to calculate it.

All Electrons that were generated with random initial angle and position with a fixed velocity Vth.

The Average time the electron can travel without collision is the Mean Free Path and it is calculated but multiplying the Thermal Velocity by the mean time between collision which is given as τ_{mn} = 0.2 ps.

$$\tau_{mn}\, x\, V_{th} = 0.37404 \text{ ns}$$

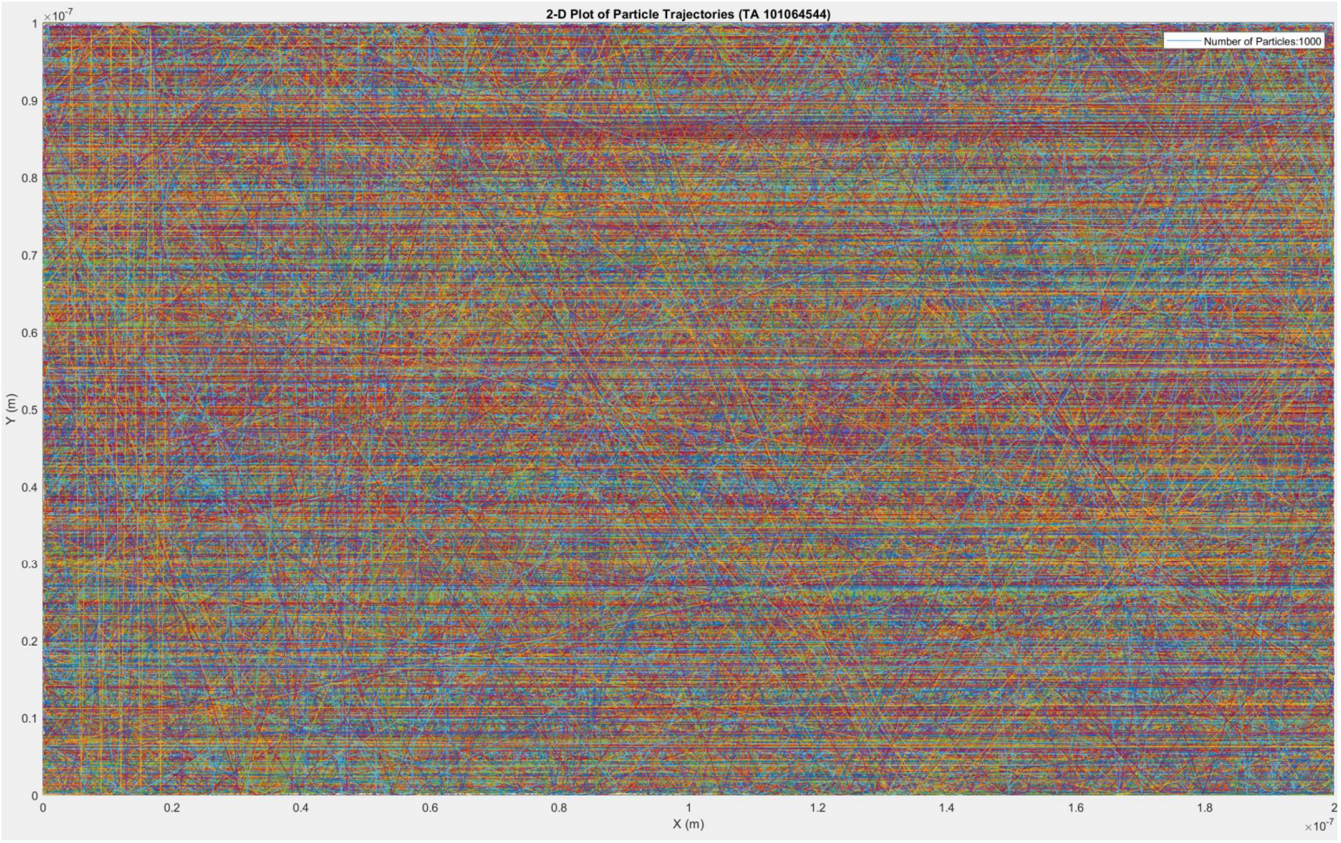

Figure 1: 2-D plot of particle trajectories for 1000 Particles

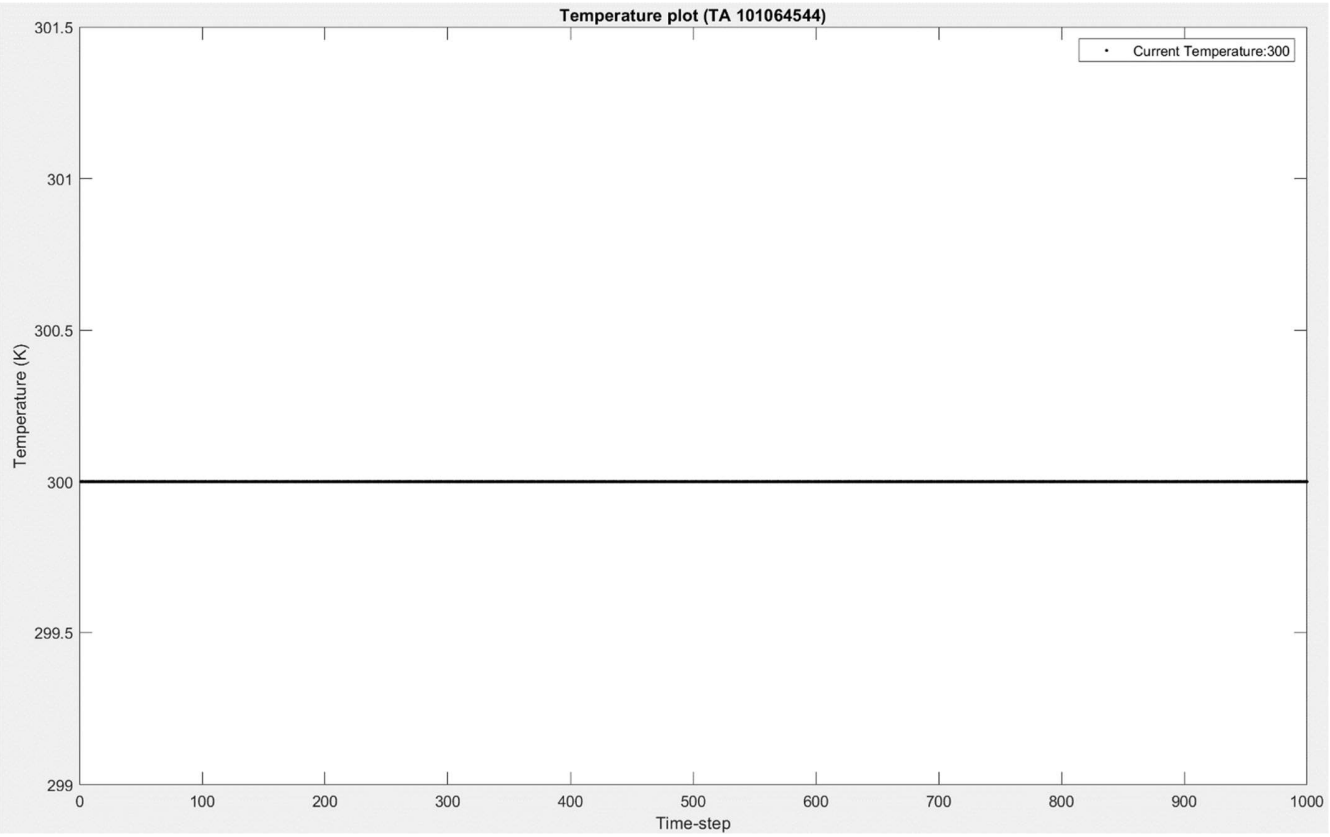

Figure 2: Temperature plot 1000 Particles

The Temperature stays at 300K throughout the whole simulation.

Part 2: Collisions with Mean Free Path (MFP)

Part 2 of the assignment, is where the Maxwell-Boltzmann distribution is used. As the electron does not have a given thermal velocity. A Histogram for 1000 Particles is shown in Figure 3 below:

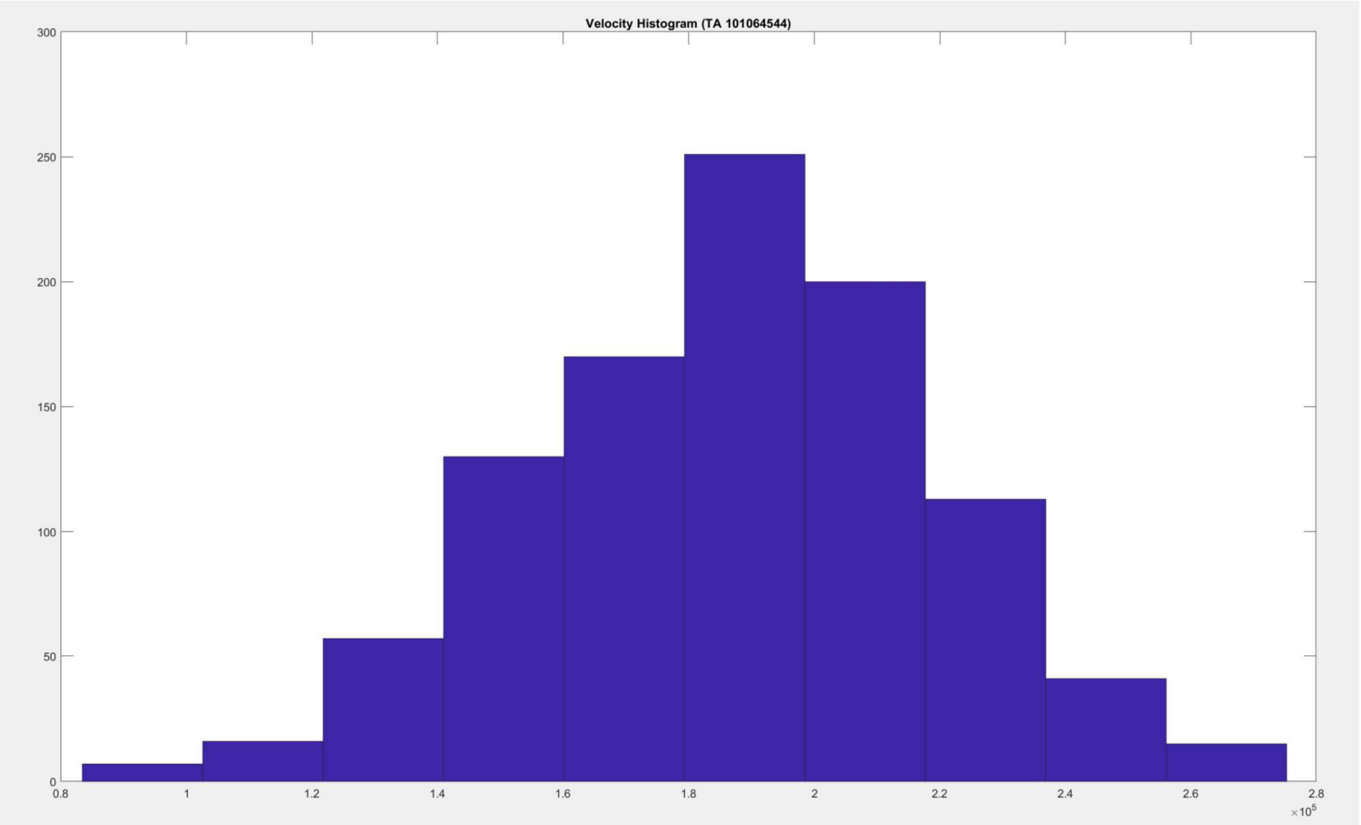

Figure 3: Velocity Histogram for 1000 Particles

In the code, the Probability scatter is calculated and can be given with the equation below, P_{scat} will scatter the electron and give it a random velocity.

$$P_{scat} = 1 - e^{-\frac{dt}{\tau_{mn}}}$$

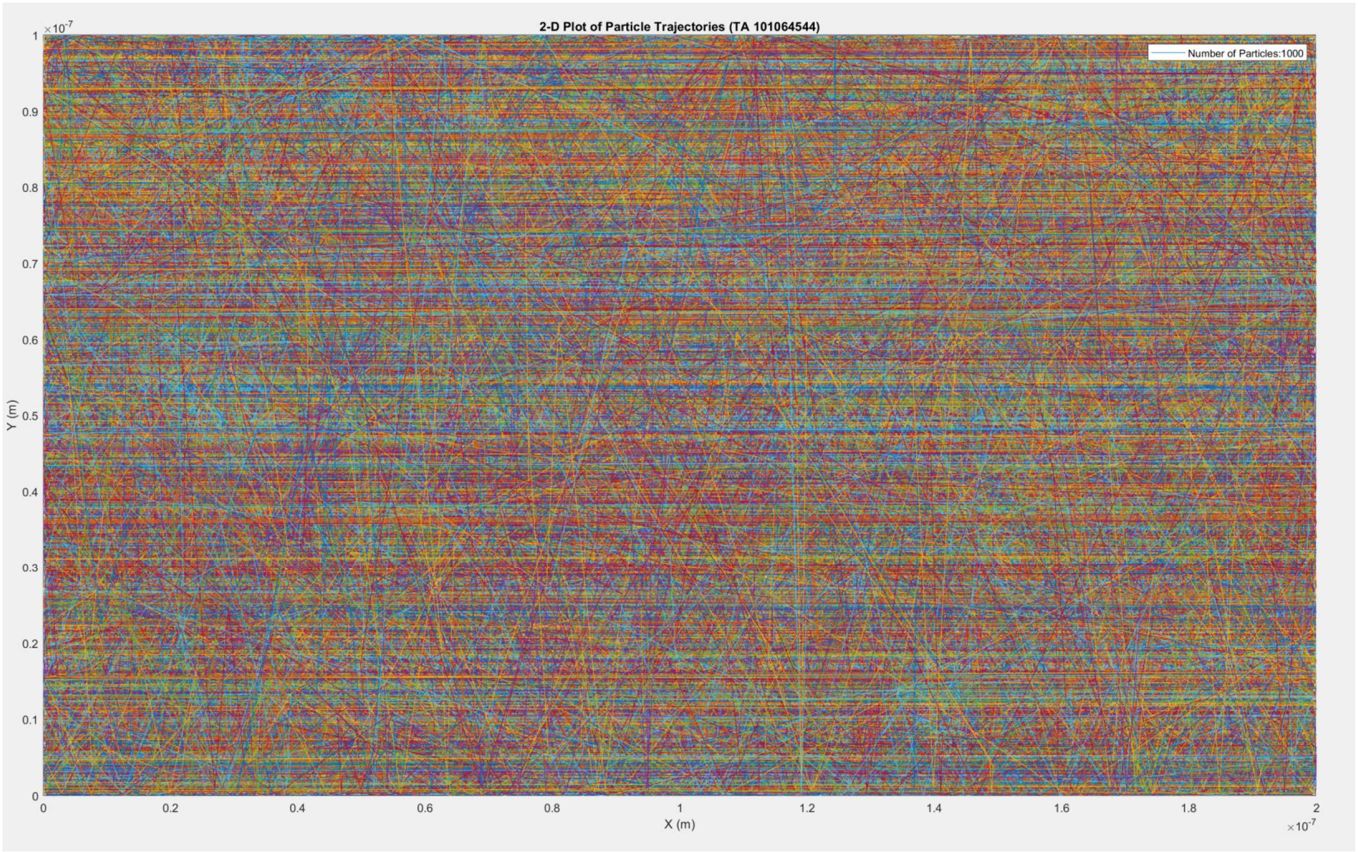

Figure 4: 2-D plot of particle trajectories for 1000 Particles

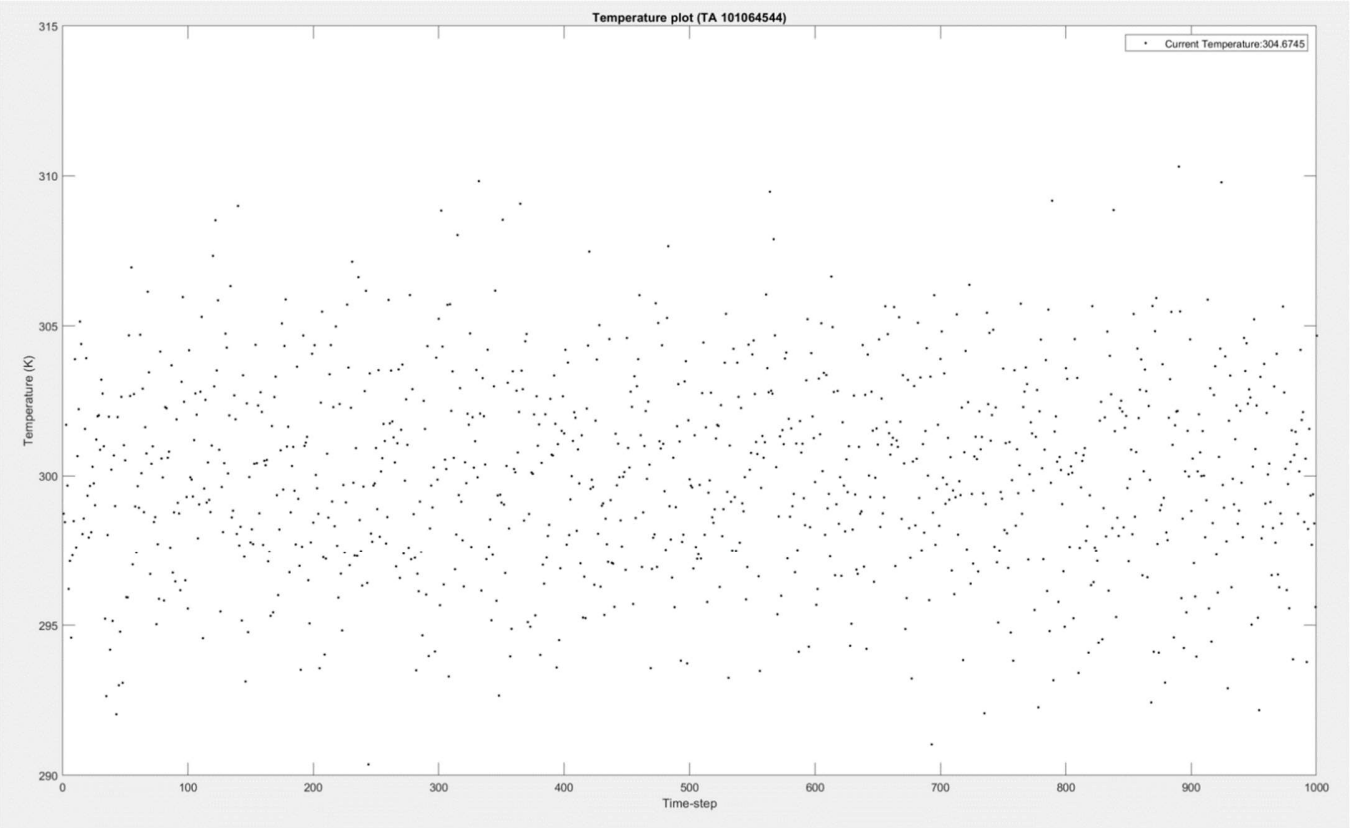

Figure 5: Temperature plot 1000 Particles

As seen in the temperature plot, the temperature is within the range of 290-310, which averages 300K.

The Mean Free Path is 3.7653×10^{-8} seconds, and the average time between collisions is 2.0221×10^{-13} seconds.

Part 3: Enhancements

In part 3, two boxes are simulated as seen in figure 6. When the particles hit the middle of the boxes it will bounce off as if it is the edge of the region.

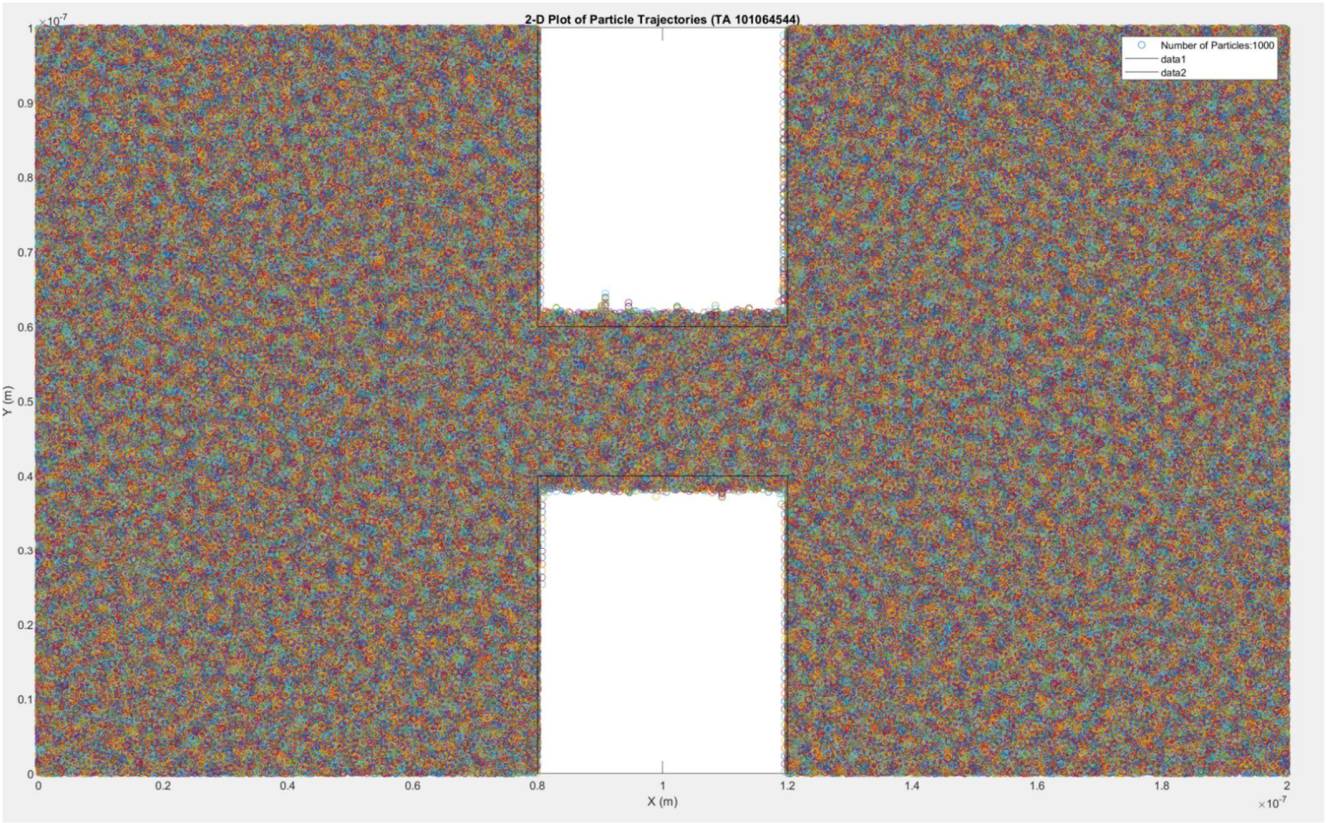

Figure 6: 2-D plot of particle trajectories for 1000 Particles with two boxes

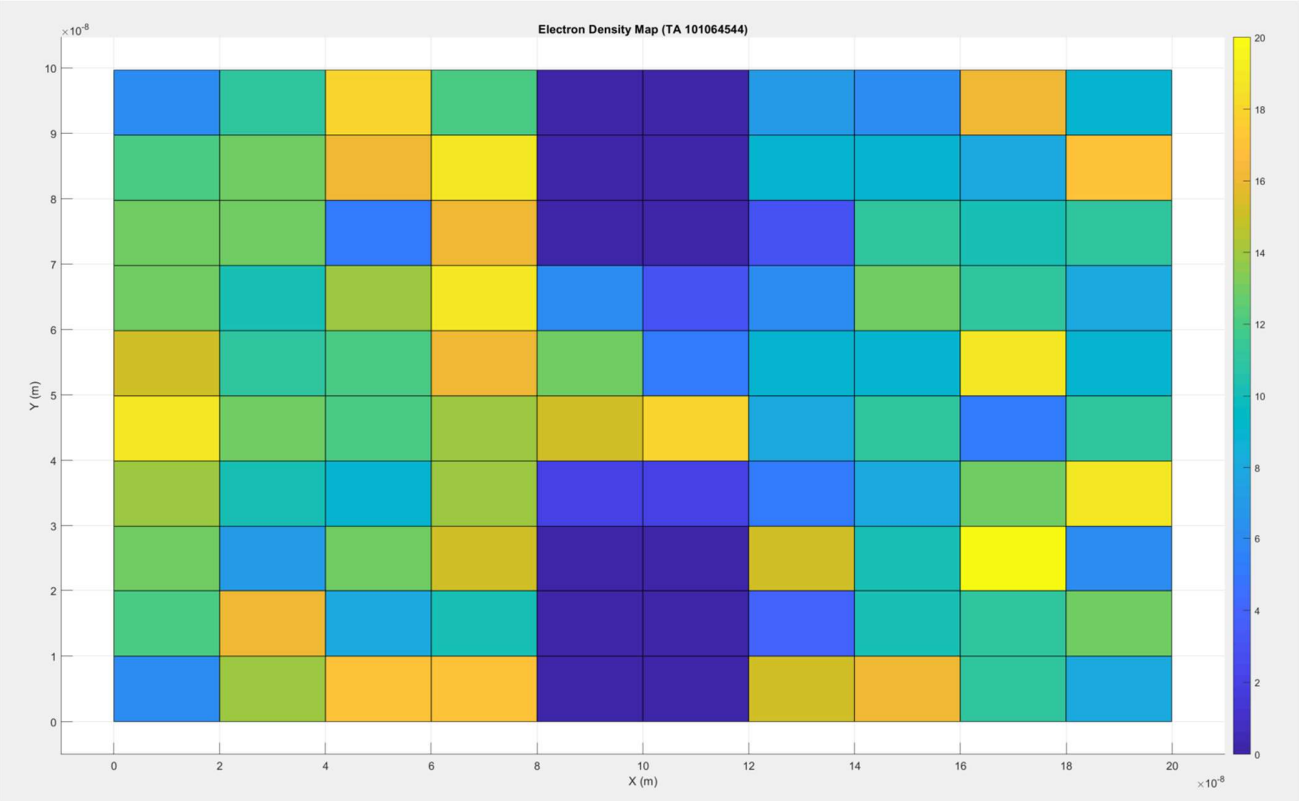

Figure 7: Electron Density Map for 1000 Particles

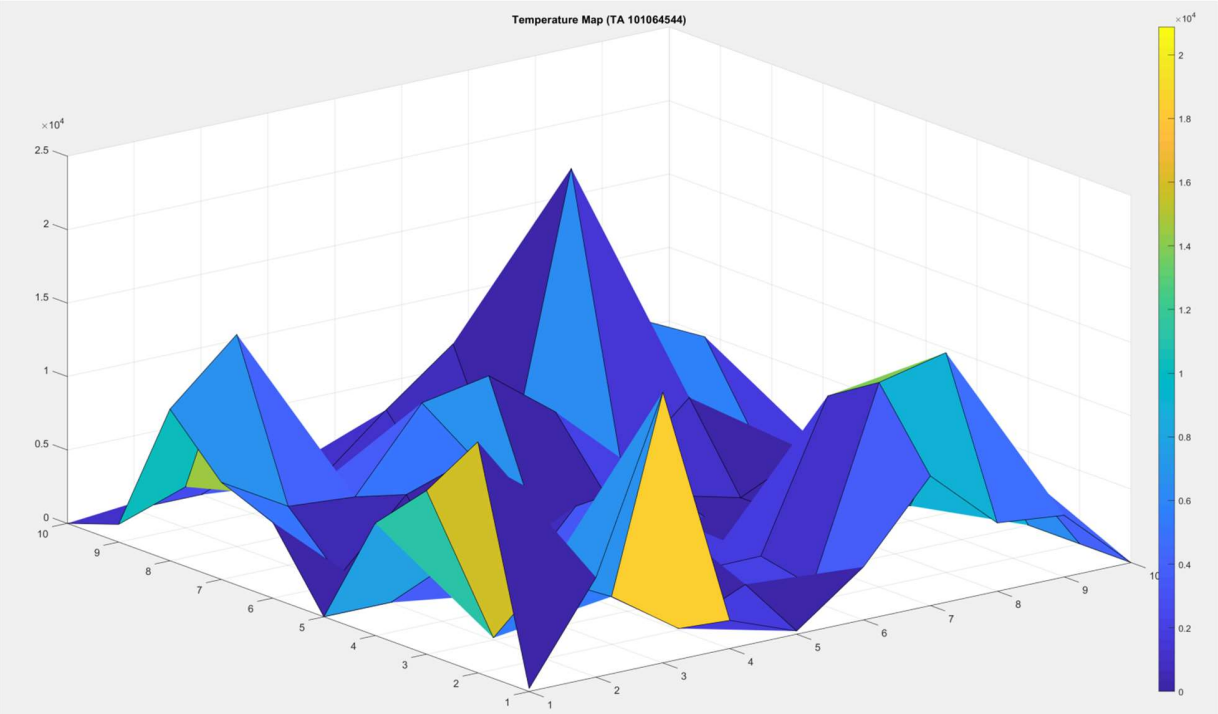

Figure 8: Temperature Map for 100 Particles