Simulation Results for system of Stochastic Differential Equations

Graphene-based Energy Harvesting
SURP 2021

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Overview

Simulation Parameters & Implementation

Plot Comparisons

Averages

Possible Avenues of Improvement

Simulation Parameters

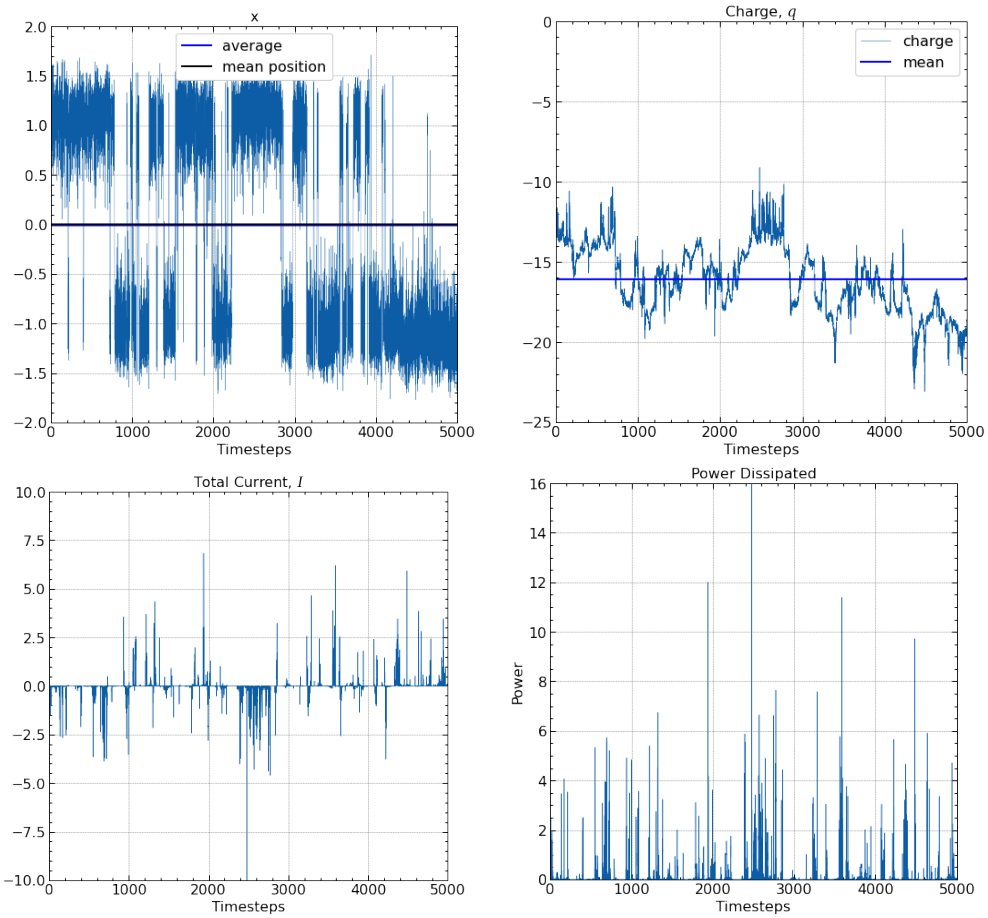
Dimensionless Constants (as given in Paper):

- $m = 1\,, I = 1\,, U_B = 4\,, R = 0.1\,, T = 0.5\,, \eta = 1\,, d = 10\,, I_0 = 0.0002$, and $T_e = 0.1$

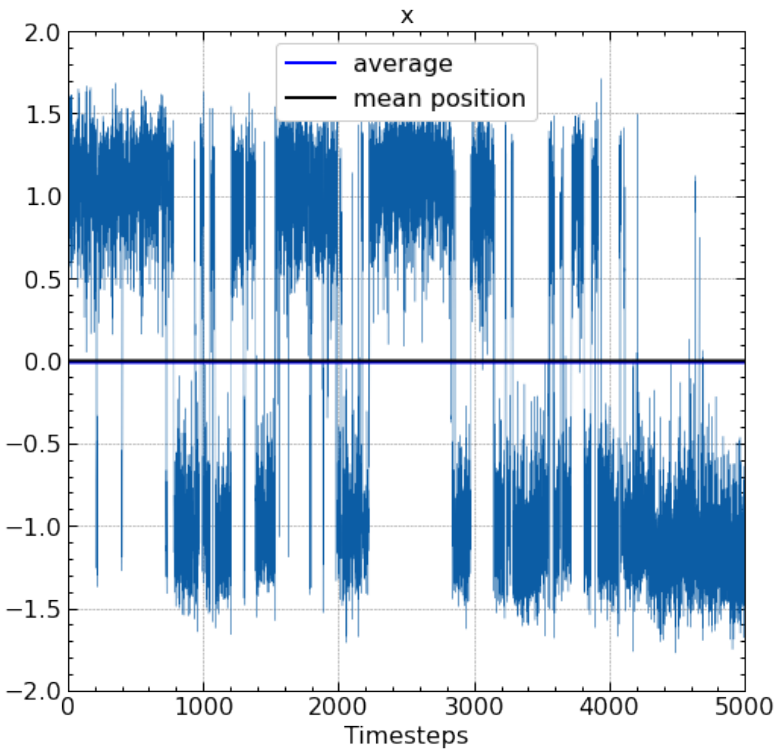
Simulation Parameters:

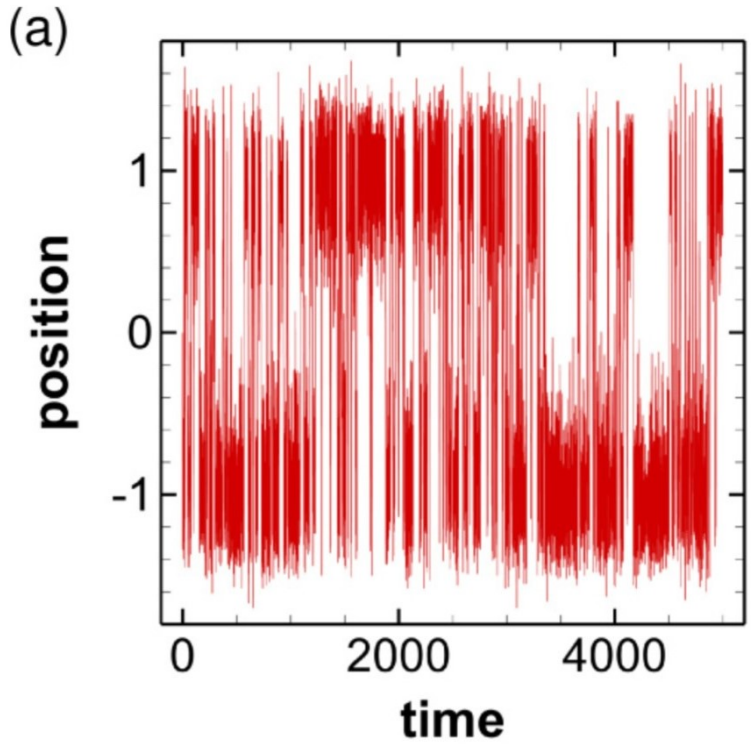
- No. of Realizations $= 40$ *(≈ 3.5 minutes/instance)* *(10^6 instances in Paper)*
- Time steps $= 10^6$ *(10×10^6 in paper)*
- Time Horizon $= 5000$ *(Important to determine whether thermal equilibrium was achieved)*

Plot Comparisons

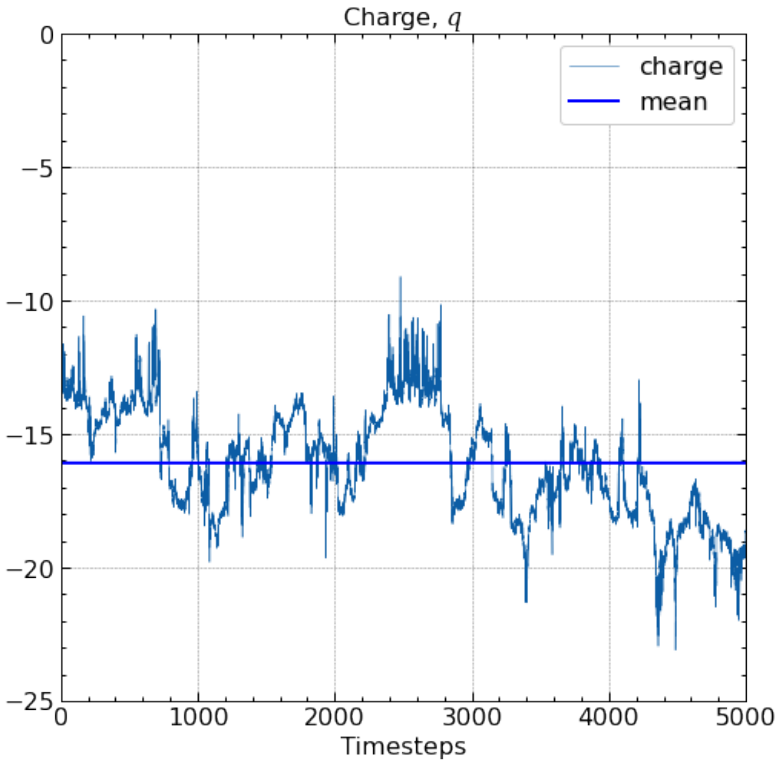


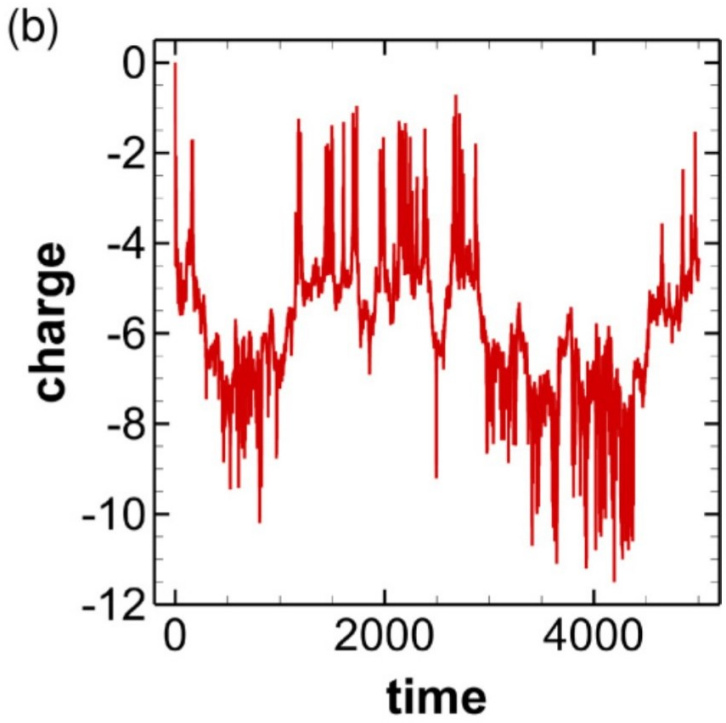
Position x


x
average
mean position
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
0
1000
2000
3000
4000
5000
Timesteps

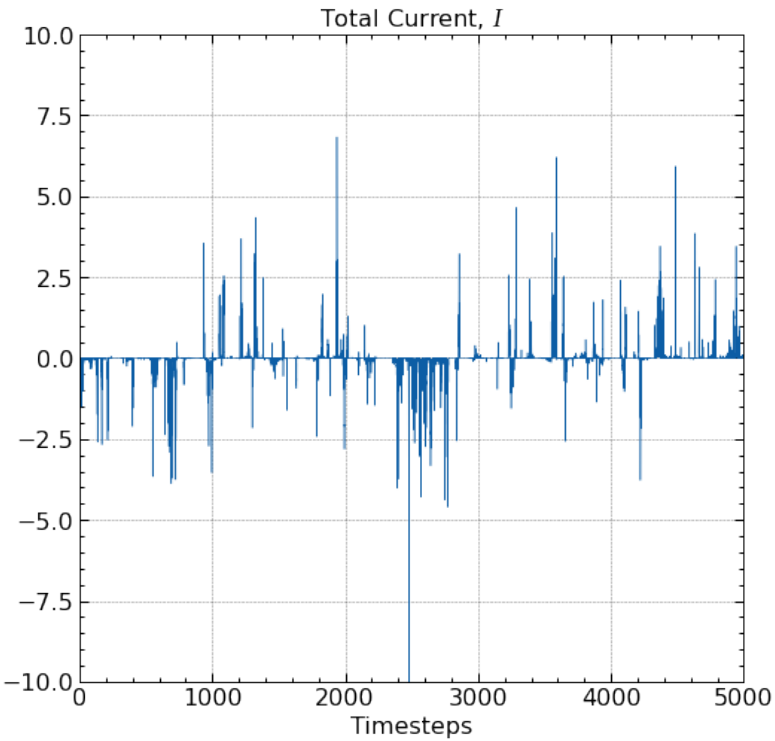

(a)
position
1
0
-1
0
2000
4000
time

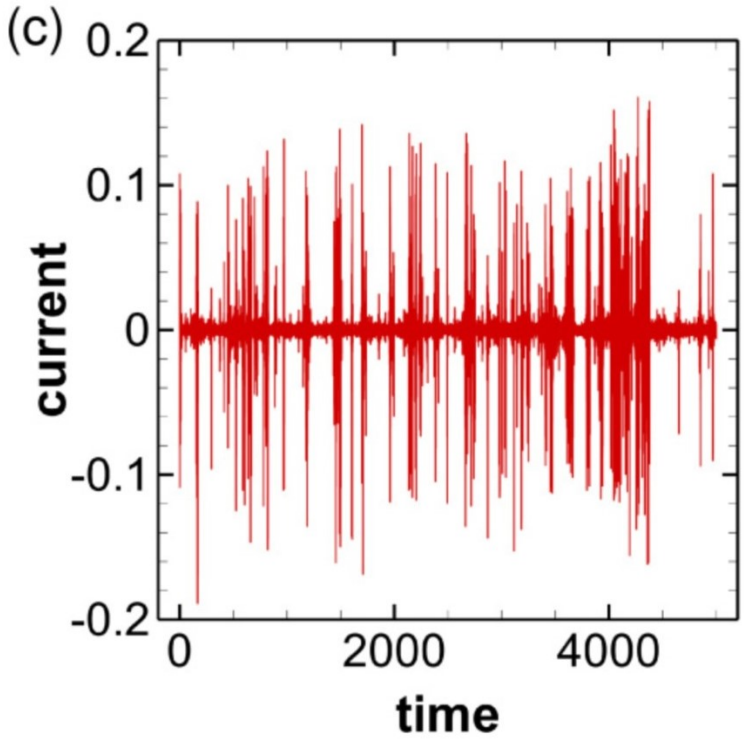
Charge q


Charge, q
charge
mean
0
−5
−10
−15
−20
−25
0
1000
2000
3000
4000
5000
Timesteps

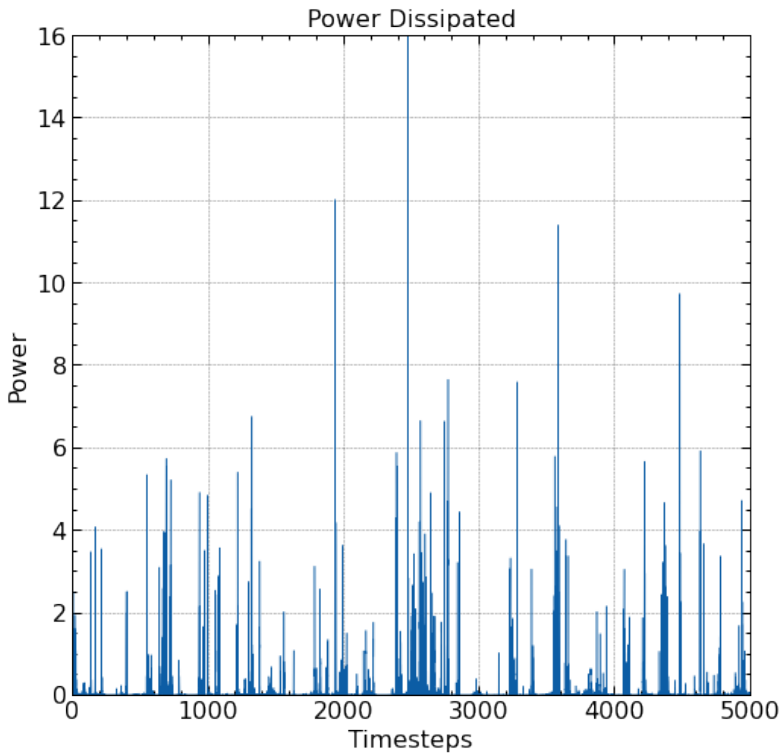

(b)
charge
0
-2
-4
-6
-8
-10
-12
0
2000
4000
time

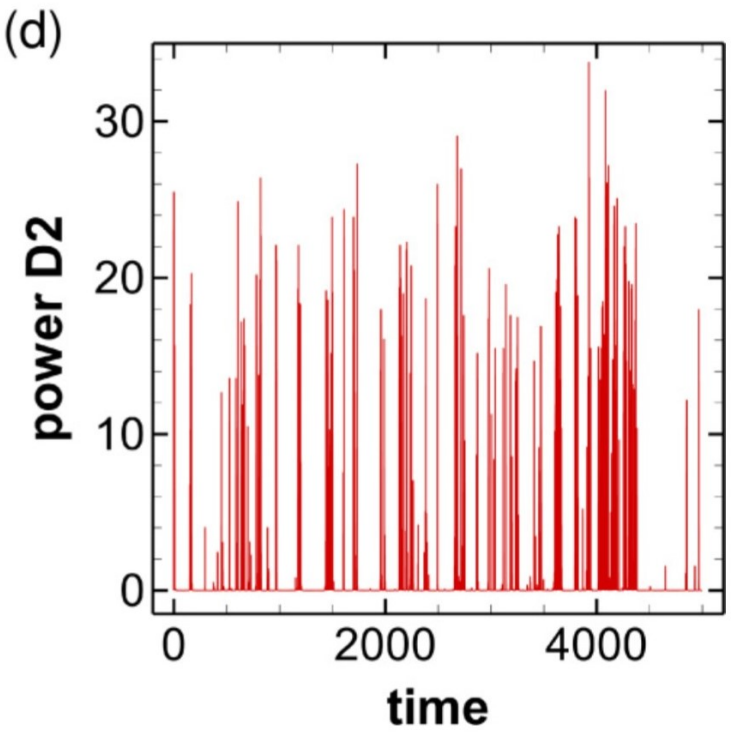
Total Current *I*





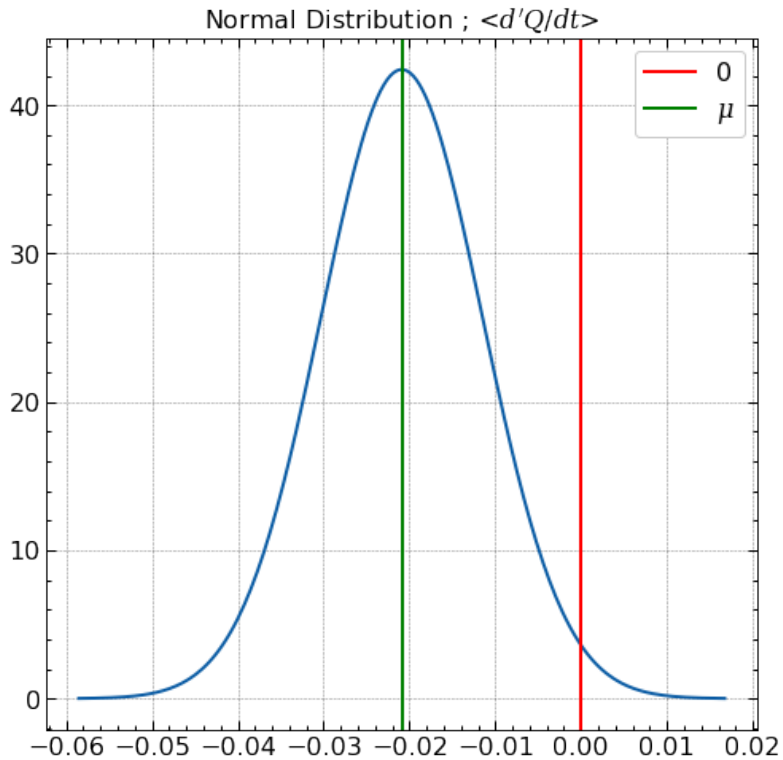
Power Dissipated P (Total)





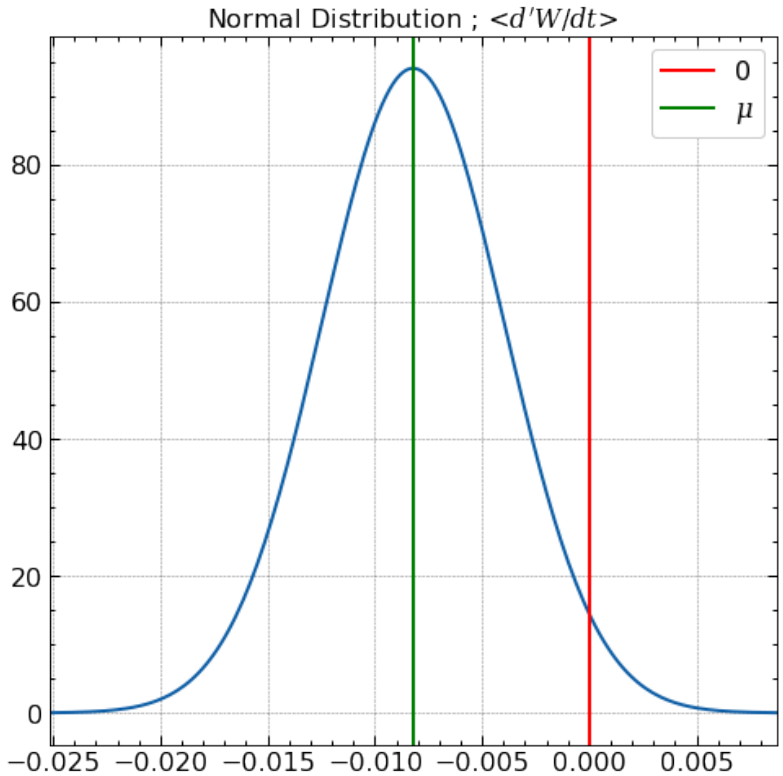
$$\left\langle \frac{d'Q}{dt} \right\rangle = \frac{\eta}{m}\left(T - \left\langle \frac{p^2}{m} \right\rangle\right)$$

- Mean := -0.02 *(observed for 40 Instances)*
- Standard Deviation := 0.009



$$\left\langle \frac{d'W}{dt} \right\rangle = \left\langle \frac{\partial}{\partial q}\left(\frac{T}{\mathcal{R}}\frac{\partial \mathcal{H}}{\partial q}\right)\right\rangle - \left\langle \frac{1}{\mathcal{R}}\left(\frac{\partial \mathcal{H}}{\partial q}\right)^2\right\rangle$$

- Mean := -0.008 *(observed for 40 Instances)*
- Standard Deviation := 0.004



Possible Avenues of Improvement

- Numerical Simulation Implementation
  - Better Numerical Derivatives (using Higher Order Numerical Derivatives or a Symbolic Manipulation Package)
  - Parallel Execution/ Vectorization
- Better Approximations/Models
  - Modified Hamiltonian to include effects of Electret; Modified circuitry
  - Accurate Capacitance Function
  - Modelling noise from power sources