Assignment No 6

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1 Introduction

In this assignment a 1D model of a tube light is simulated. A uniform electric field is present, that accelerates electrons. Electrons are emitted by the cathode with zero energy, and accelerate in this field. When they get beyond a threshold energy E_0, they can drive atoms to excited states. The relaxation of these atoms results in light emission.

2 Taking input from user or using predifined parameters

```
if len(sys.argv)==6:
    n=sys.argv[0]       # spatial grid size.
    M=sys.argv[1]       # number of electrons injected per turn.
    nk=sys.argv[2]      # number of turns to simulate.
    u0=sys.argv[3]      # threshold velocity.
    p=sys.argv[4]       # probability that ionization will occur
    Msig=sys.argv[5]    # deviation of elctrons injected per turn
    param = [n,M,nk,u0,p,Msig]
else:
    param = [100,5,500,5,0.25,2]
```

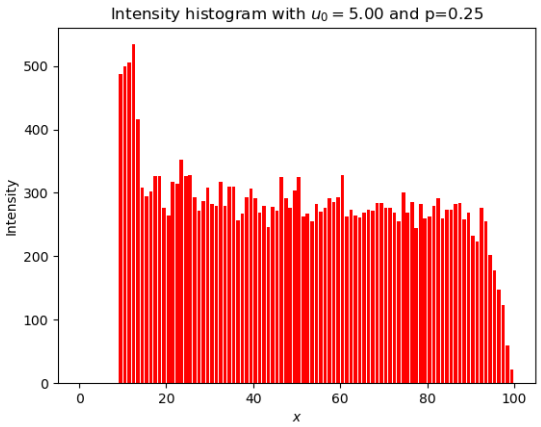
3 The Simulation Loop

```
def simulate(params):
    n = params[0]
    M = params[1]
    nk = params[2]
    u0 = params[3]
    p = params[4]
    Msig = params[5]
    xx = np.zeros((n*M))  # electron position
```

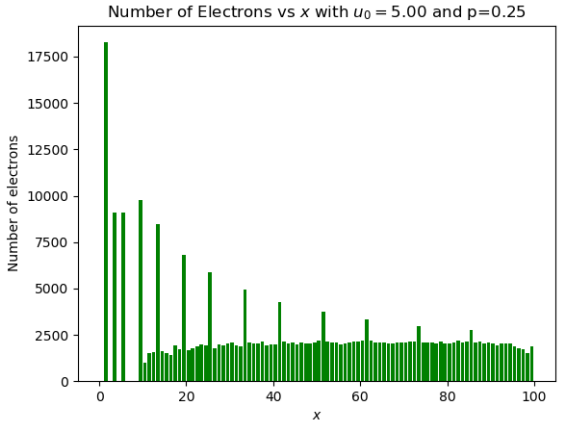
```
u = np.zeros((n*M))   # electron velocity
dx = np.zeros((n*M))  # displacement in current turn

I = []
V = []
X = []

for i in range(1, nk):
    ii = where(xx>0)                #indices of positions greater
                                    #than zero
    dx[ii] = u[ii] + 0.5            #displacement
    xx[ii] += dx[ii]                #update position
    u[ii] += 1                      #update velocity

    overshoot = where(xx[ii]>n)     #contains the indices whose disp,
                                    #vel, pos have to set to 0
    xx[ii[0][overshoot]] = 0
    u[ii[0][overshoot]] = 0
    dx[ii[0][overshoot]] = 0


    kk = where(u>=u0)               #v greater than threshold
    ll = where(rand(len(kk[0])) <= p)
    kl=kk[0][ll]                    #contains the indices of energetic
                                    #electrons that suffer collision
    u[kl]=0                         #velocity becomes 0 after collision

    rho = rand(len(kl))
    xx[kl] = xx[kl]-dx[kl]*rho      #actual value of x where it collides

    I.extend(xx[kl].tolist())

    m = int(rand()*Msig + M)        #number of new electrons to be added
    vacant = where(xx==0)           #empty spaces where electrons
                                    #can be injected
    nv=(min(n*M-len(vacant),m))
    xx[vacant[:nv]]=1               #inject the new electrons
    u[vacant[0][:nv]]=0             #velocity zero
    dx[vacant[0][:nv]]=0            #displacement zero
    X.extend(xx.tolist())
    V.extend(u.tolist())
return X,V,I
```

4 The different plots

plot_intensity to plot the intensity vs x.

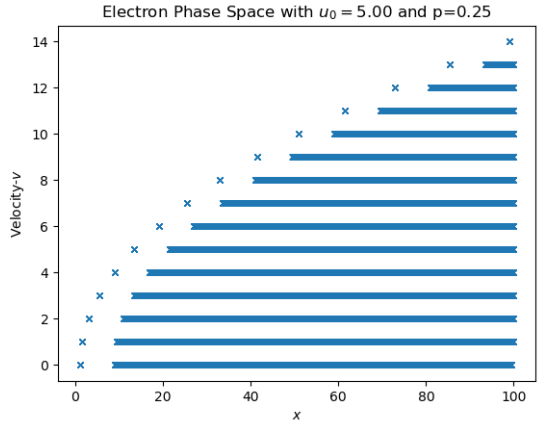


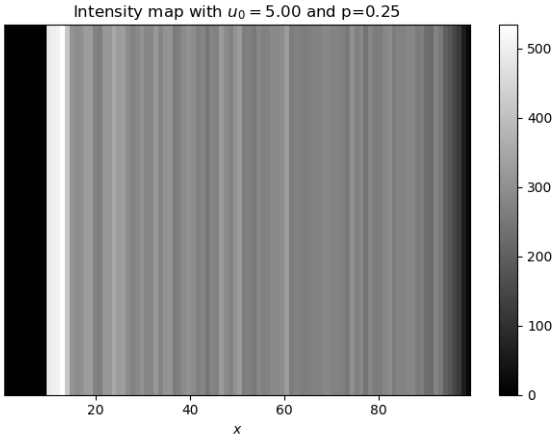
plot_no_of_elec to plot the number of electrons vs x.



plot_phase_space to plot the phase space of electrons.

plot_intensity_map to plot the relative brightness of the tubelight in greyscale.





5 Table of count vs xpos

xpos	count
0.5	0.0
1.5	0.0
2.5	0.0
3.5	0.0
4.5	0.0
5.5	0.0
6.5	0.0
7.5	0.0
8.5	0.0
9.5	487.0
10.5	499.0

11.5	506.0
12.5	534.0
13.5	416.0
14.5	309.0
15.5	294.0
16.5	302.0
17.5	327.0
18.5	326.0
19.5	277.0
20.5	265.0
21.5	317.0
22.5	315.0
23.5	353.0
24.5	326.0
25.5	328.0
26.5	293.0
27.5	272.0
28.5	287.0
29.5	309.0
30.5	283.0
31.5	280.0
32.5	317.0
33.5	280.0
34.5	310.0
35.5	310.0
36.5	257.0
37.5	268.0
38.5	293.0
39.5	307.0
40.5	292.0
41.5	269.0
42.5	279.0
43.5	246.0
44.5	278.0
45.5	272.0
46.5	325.0
47.5	292.0
48.5	277.0
49.5	304.0
50.5	325.0
51.5	263.0
52.5	267.0
53.5	255.0
54.5	283.0

55.5	271.0
56.5	276.0
57.5	291.0
58.5	286.0
59.5	293.0
60.5	328.0
61.5	262.0
62.5	273.0
63.5	264.0
64.5	261.0
65.5	269.0
66.5	274.0
67.5	272.0
68.5	284.0
69.5	284.0
70.5	277.0
71.5	276.0
72.5	269.0
73.5	255.0
74.5	300.0
75.5	269.0
76.5	285.0
77.5	244.0
78.5	283.0
79.5	260.0
80.5	262.0
81.5	280.0
82.5	292.0
83.5	260.0
84.5	273.0
85.5	273.0
86.5	283.0
87.5	284.0
88.5	258.0
89.5	269.0
90.5	232.0
91.5	224.0
92.5	276.0
93.5	255.0
94.5	202.0
95.5	178.0
96.5	148.0
97.5	123.0
98.5	59.0

```
| 99.5 |  22.0 |
+------+-------+
```

6 Conclusion

In the intensity vs x graph, the intensity reaches a maximum at around x = 15 and stays like that for around 5 bins and then decreases. This is because of the fact that the electron comes to rest after collision. Thus it has to gain energy from zero to be able to excite the atom for emmission of light. In the electron phase space graph, we can see from the graph the allowed velocities at a particular x. Thus we can say that the velocities are quantized. The number of electrons vs x graph shows the number of electrons which got excited at that value of x.