Four State Model

Version-3

In this model the increment in time(tinc) in each state is given by -log(f)/Σrates where f is a random number. The probability of electron for going in a particular state is rate/Σrates.

Code:

```
clear;
clc;
close all;
tic
tau1=4e-9;  %for transition from state 2 to 1
tau2=1e-9;  %for transition from state 3 to 2
tau=0.24;    %for transition from state 4 to 1
taua=10e-9; %for transition from state 3 to 4
s1=1e-15;   %cross section of NC
s2=1e-15;   %cross section of NC
h=2.5*1.6e-19;
I=0.08e3;   %intensity
W1=s1*I/h;  %rate of transition from state 1 to 2
W2=s2*I/h;  %rate of transition from state 2 to 3
bin_size=10e-3;
trap=0; %count total number of trap states(3 to 4)
on=0;   %count total number of on states(2 to 1)
i=2;    %index for array
n=2000000;%total number of iterations
t(1)=0;  %time array
next(1)=1;%stores the sequence of states with initial state as 1
on(1)=0;
%[next(2), tinc(1),tr,on1]=state_n(next(1), W1,W2,tau1,tau2,taua,tau); %next state is determined
%on(2)=on1;
%t(2)=t(1)+tinc(1);
while i<=n
   [next(i), tinc(i-1),tr,on1,f,num]=state_n1(next(i-1),W1,W2,tau1,tau2,taua,tau); %iteratively next state is
determined
   trap=trap+tr;
   on(i)=on1;
   t(i)=t(i-1)+tinc(i-1);

   F(i-1)= f;
   N(i-1) = num;
   i=i+1;
end
n2=fix(max(t)/bin_size);        %number of bins formed
```

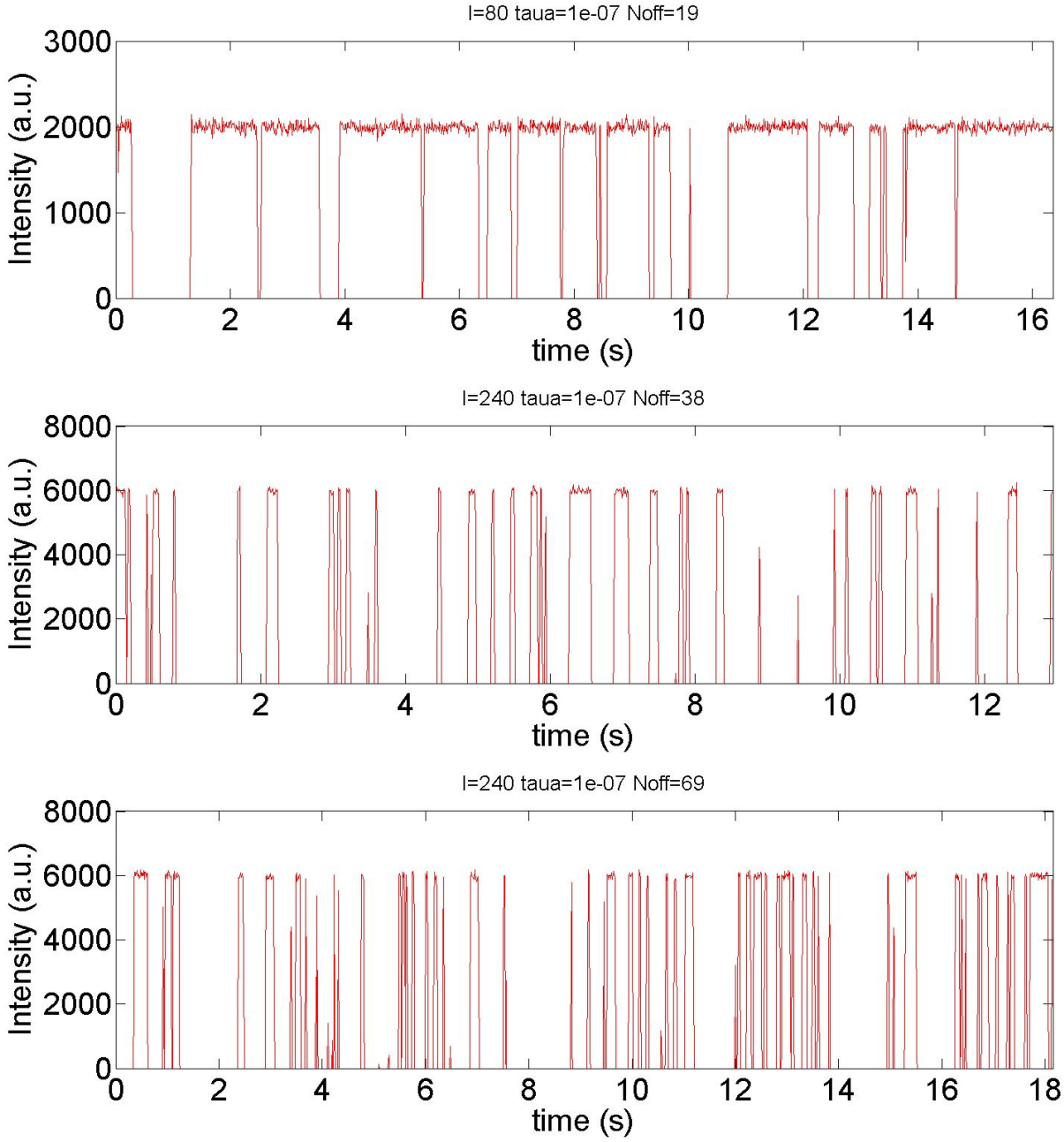
```
binranges=0:bin_size:max(t);    %stores the various bins
[bincounts, ind]=histc(t,binranges);% bincounts stores the number of indices of t array in each bin
sr=1;
for y=1:n2 %binning method
  on2(y)= sum(on(sr:bincounts(y)+sr));
  st=bincounts(y)+1;
end
t1 = 0:bin_size:(n2-1)*bin_size;
c = [[0,0,0];[0.7,0.7,0.7];[1,0,0];[0,1,0];[0,0,1]];
line_style = {'-','--','-.','-'};
   plot(t1,on2,'Color', [c(3,:)],'LineStyle',line_style{1});
   xlim([0, max(t)]);

   %h_legend = legend('3 level','Location','NorthEast');
   title(['I=',num2str(I),' taua=',num2str(taua),' Noff=',num2str(trap)],'fontsize',16);
 %   set(h_legend,'fontsize',16, 'box', 'off');
   xlabel('time (s)','fontsize',24);
   ylabel('Intensity (a.u.)','fontsize',24);
   set(gca, 'Fontsize',24);

   figname_png = ['Intensity and time for 4 state model 7.png'];
   figname = ['Intensity and time for 4 state model 7'];
   width = 30;
   height = 10;
   set(gcf, 'PaperPositionMode', 'manual');
   set(gcf, 'PaperSize', [width height]);
   set(gcf, 'PaperPosition', [0 0 width height]);
   set(gca,'position',[0.1 0.19 .85 .7]);% specify these as the fraction of the total.. between 0 and 1

   print('-dpng','-r125',figname_png);
toc
```

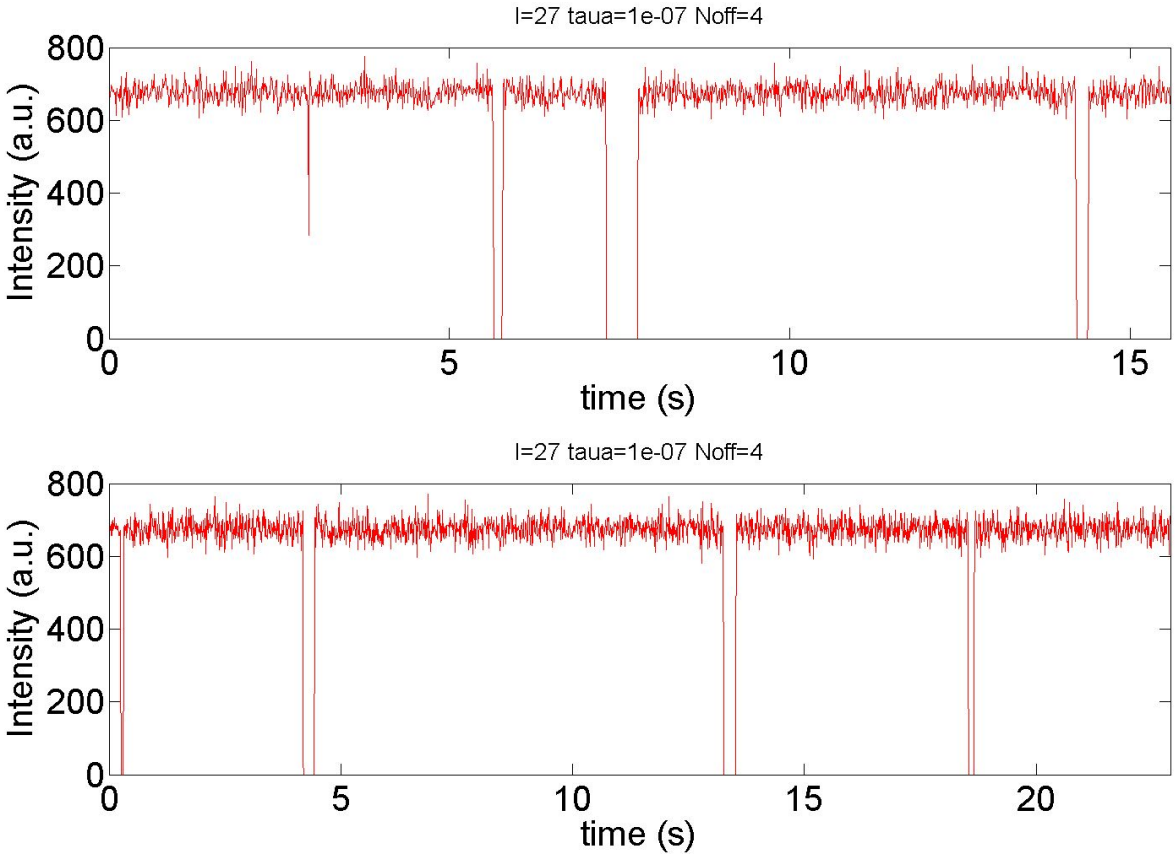
Function:

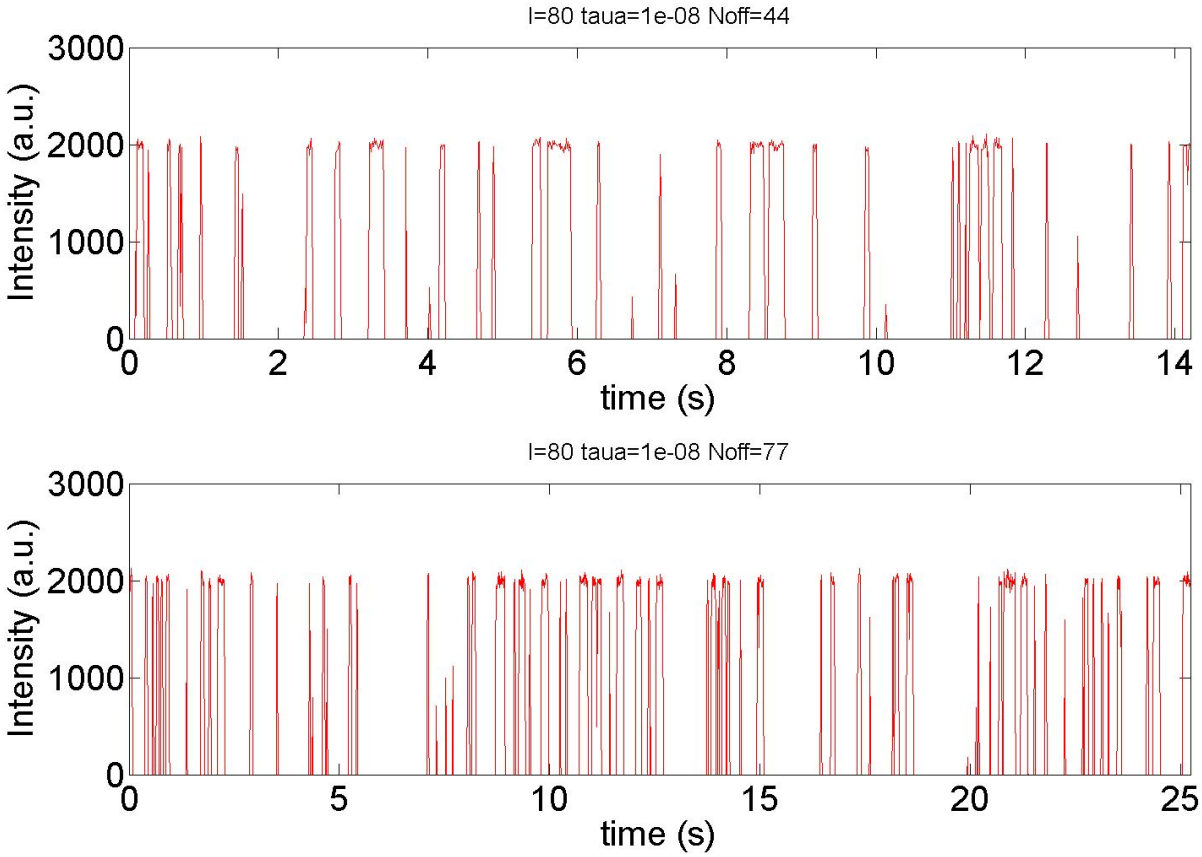
```
% state1 is with 0 e-h pair, state2 is with one e-h pair
% state3 is with 2 e-h pairs, state4 is the trap state

function [next, tinc,tr,on1,f,num] =state_n1(st, W1,W2,tau1,tau2,taua,tau)
tr=0;
on1=0;
f=rand();
if st==1
   tinc=-log(f)/(W1);
   norm=1/W1;
   num=rand();
   if(num<W1*norm)
      next=2;
   else
      next=1;
```

```
    end
end
if st==2
    tinc=-log(f)/(W2+(1/tau1));
    norm=1/(W2+(1/tau1));
    num=rand();
    if(num<W2*norm)
        next=3;
    elseif (W2*norm<=num && num<(W2+(1/tau1))*norm)
        next=1;
        on1=1;
    else
        next=2;
    end
end
if st==3
    tinc=-log(f)/((1/tau2)+(1/taua));
    norm=1/((1/tau2)+(1/taua));
    num=rand();
    if(num<(1/tau2)*norm)
        next=2;
    elseif((1/tau2)*norm<=num && num<((1/tau2)+(1/taua))*norm)
        next=4;
        tr=1;
    else
        next=3;
    end
end
if st==4
    tinc=-log(f)/(1/tau);
    norm=1/(1/tau);
    num=rand();
    if(num<(1/tau)*norm)
        next=2;
    else
        next=4;
    end
end
end
```

Results:


I=80 taua=1e-07 Noff=19
Intensity (a.u.)
time (s)
I=240 taua=1e-07 Noff=38
Intensity (a.u.)
time (s)
I=240 taua=1e-07 Noff=69
Intensity (a.u.)
time (s)


I=27 taua=1e-07 Noff=4
Intensity (a.u.)
800
600
400
200
0
0
5
10
15
time (s)
I=27 taua=1e-07 Noff=4
Intensity (a.u.)
800
600
400
200
0
0
5
10
15
20
time (s)


I=80 taua=1e-08 Noff=44
Intensity (a.u.)
3000
2000
1000
0
0
2
4
6
8
10
12
14
time (s)
I=80 taua=1e-08 Noff=77
Intensity (a.u.)
3000
2000
1000
0
0
5
10
15
20
25
time (s)