Three Level System

Code:

```
clear;
clc;
close all;
tic
n=1; %current iteration
n1=1000000;%total number of iterations
p=10000; %pumping rate
LT=10e-9;  %initialised here, follows exponential distribution
T=exprnd(LT,1,n1);
gnr1=1000; %rate of going from excited to trap state
gnr2=1;  %rate of going from trap to ground state
bin_size=10^-2;  %size of each bin

t(1)=0; % stores time at which intensity is measured
intensity(1)=0; %intensity at a particular time
i=2; %index for time array
j=2; %index for intensity array
k=1; %index for choose array
q=1; %index for gsp1 array(array of gsp)
c=1; %index for iterating over time while binning
count=0; %number of time it goes in trap state
while n<=n1
    gsp1=1./T(n); %random number generated for gsp from exponential distribution
   %{
       while gsp<10^7  % put limit to value of gsp
        gsp=exprnd(10^8);
       end
        %}

S3=sqrt(p.^2-2*p*gnr1-2*p*gnr2+2*p*gsp1+gnr1.^2-2*gnr1*gnr2+2*gnr1*gsp1+gnr2.^2-
2*gnr2*gsp1+gsp1.^2)/2;
    S2=p/2 +S3 +gsp1/2 +gnr1/2 +gnr2/2;
    S1=p/2 -S3 +gsp1/2 +gnr1/2 +gnr2/2;
    A1=(p*gnr1)/(p*gnr1+p*gnr2+gnr1*gnr2+gnr2*gsp1);
    A2=(S1/(2*S3))*A1;
    A3=-(S2/(2*S3))*A1;
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```
   gsp2(q)=gsp1; %store gsp in gsp1
   choose(k)=rand();  %random number from 0 to 1 for choosing which state it goes
   if choose(k)<(gnr1/(gsp1+gnr1)) % case when carrier goes into trap state
      intensity(j)=0;
      j=j+1;
      t(i)=t(i-1)+ 1/gnr1 +1/gnr2; %rise in time
      count=count+1;
      h=fix((1/gnr1 +1/gnr2)/(1/p));
      t(i)=t(i)+(h+1)*(1/p) - 1/gnr1 +1/gnr2;
      i=i+1;
   else  %case when it goes to ground state directly
      t(i)=t(i-1)+1/gsp1; %rise in time

intensity(j)=(gsp1^2/(gsp1+gnr1))*((gnr2*A1/gnr1)+((gnr2-S2)/gnr1)*A2*exp(-S2/gsp1) +
((gnr2-S1)/gnr1)*A3*exp(-S1/gsp1));  % function for intensity
      g=fix((1/gsp1)/(1/p));
      t(i)=t(i)+(g+1)*(1/p) - 1/gsp1;
      i=i+1; %increment in time index
      j=j+1;  %increment in intensity index

   end


   k=k+1;
   n=n+1;
   q=q+1;
end
plot(t, intensity,'o')
figure()
n=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
%len=length(bincounts);
st=1;

for y=1:n %binning method
  %ran=st:bincounts(y);
  i1(y)= sum(intensity(st:bincounts(y)+st));
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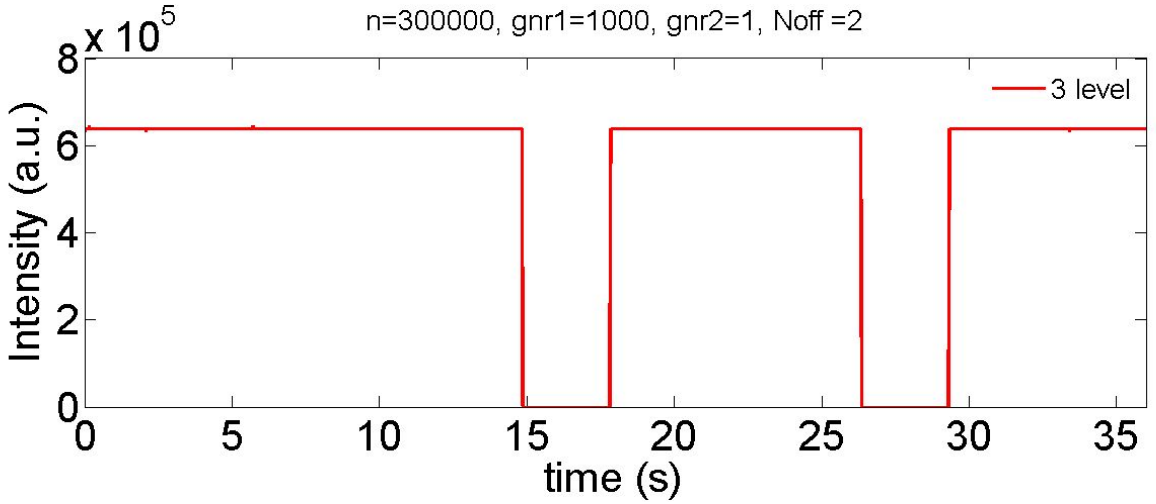
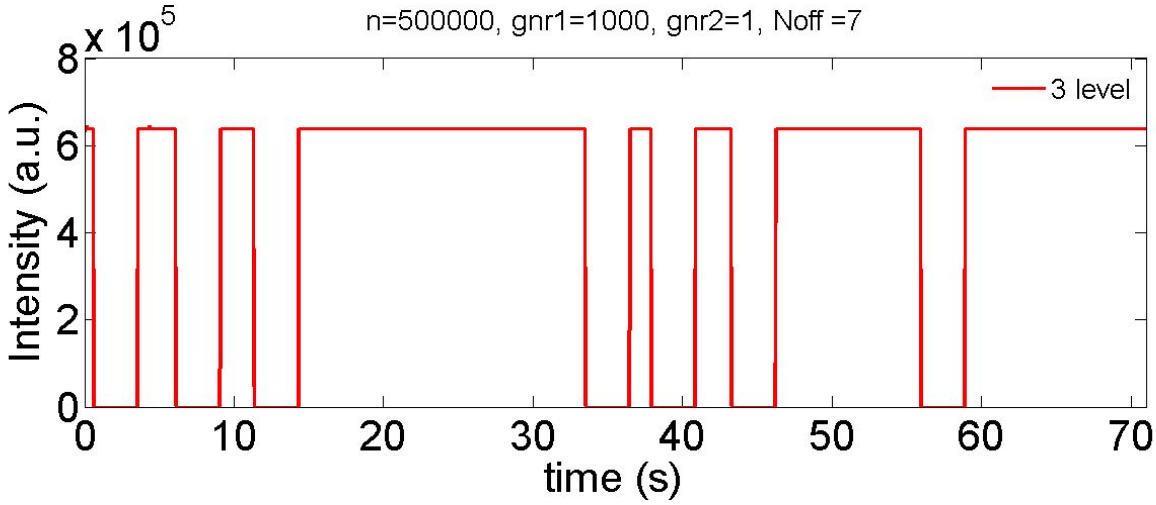
```
   st=bincounts(y)+1;
end

%{
i1=zeros(n,1); %array initialized with zero to store intensity after binning
for m=1:n %iterating over each bin
 cprev=c;
   while t(c)<m*bin_size
      i1(m)=i1(m)+intensity(c);
      c=c+1;
   end
   diff=c-cprev;
  %average of intensity is stored after binning
end
%}
i1(isnan(i1)) =0;%replace all NaN to 0 in i1 array
t1 = 0:bin_size:(n-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,i1,'LineWidth',2,'Color', [c(3,:)],'LineStyle',line_style{1});
    xlim([0, max(t)]);

    h_legend = legend('3 level','Location','NorthEast');
    title(['n=',num2str(n1),', gnr1=',num2str(gnr1),', gnr2=',num2str(gnr2), ', Noff
=',num2str(count)],'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 3 level system(histc binning)5.png'];
    figname = ['Intensity and time for 3 level system(histc binning)5'];
    width = 25;
    height = 10;
    set(gcf, 'PaperPositionMode', 'manual');
    set(gcf, 'PaperSize', [width height]);
    set(gcf, 'PaperPosition', [0 0 width height]);
```

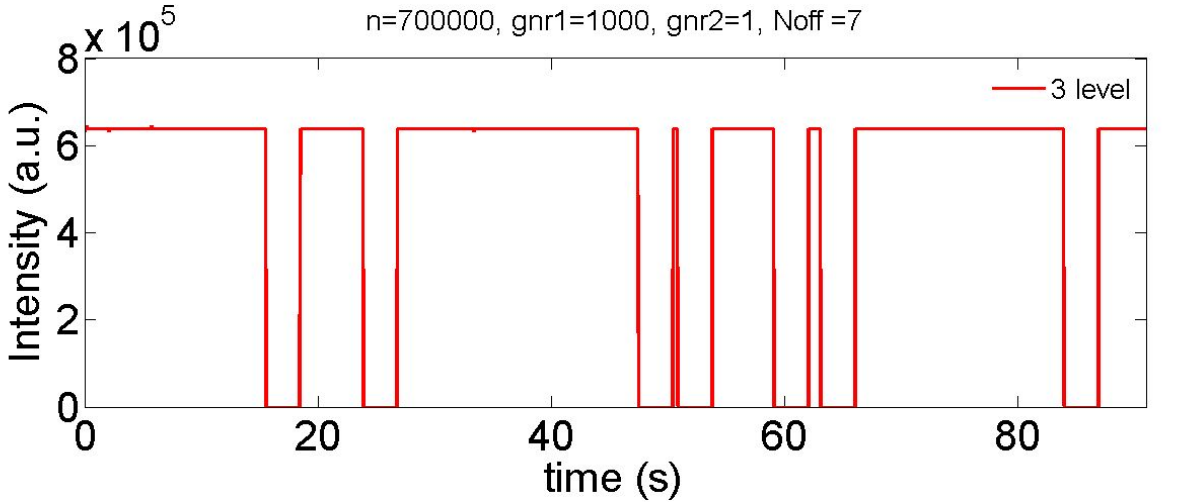
```
    set(gca,'position',[0.1 0.19 .85 .7]);% specify these as the fraction of the total..
between 0 and 1

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

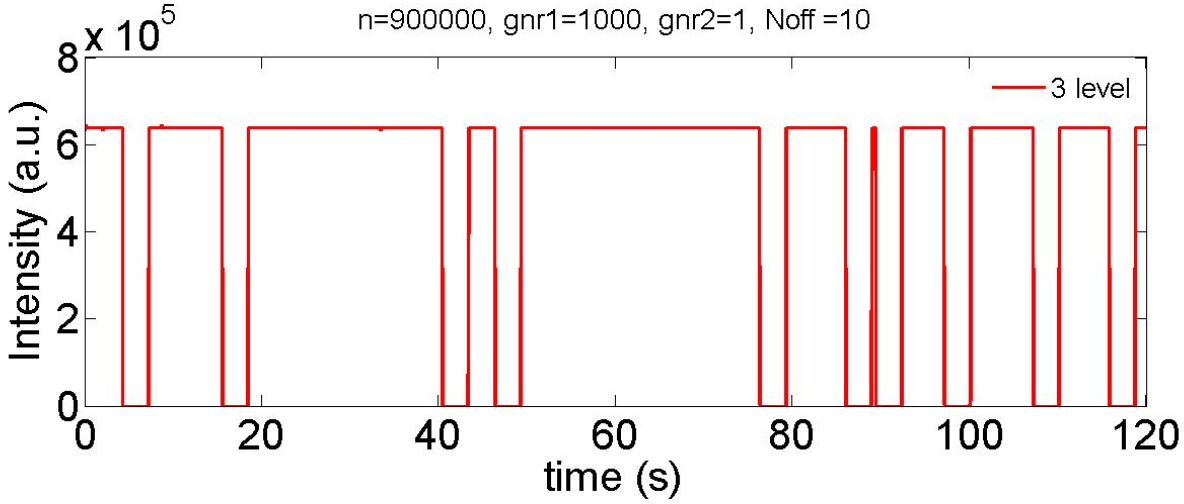
Results:

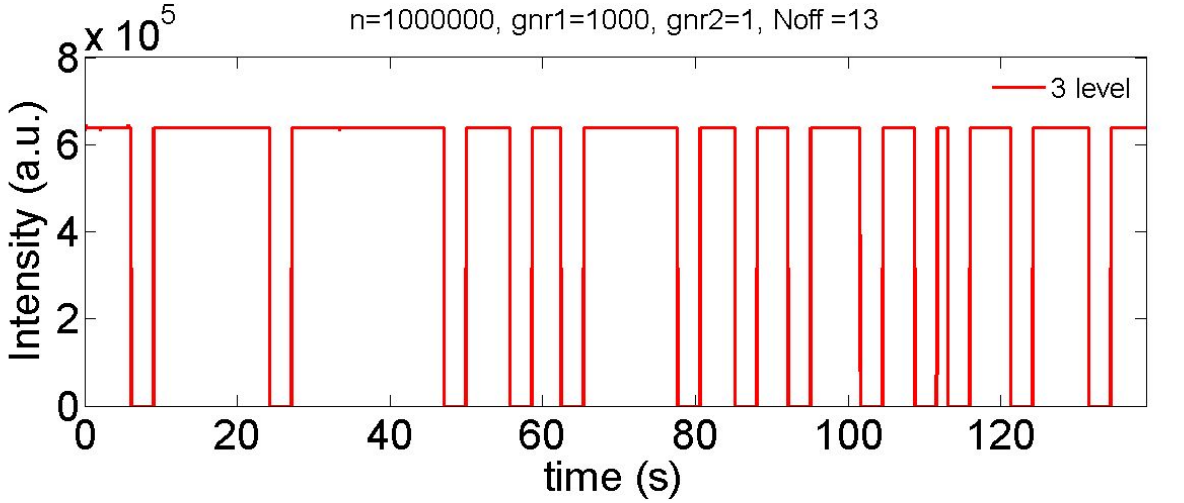
gnr1=1000, gnr2=1, p=10000, lifetime = 10 nsec

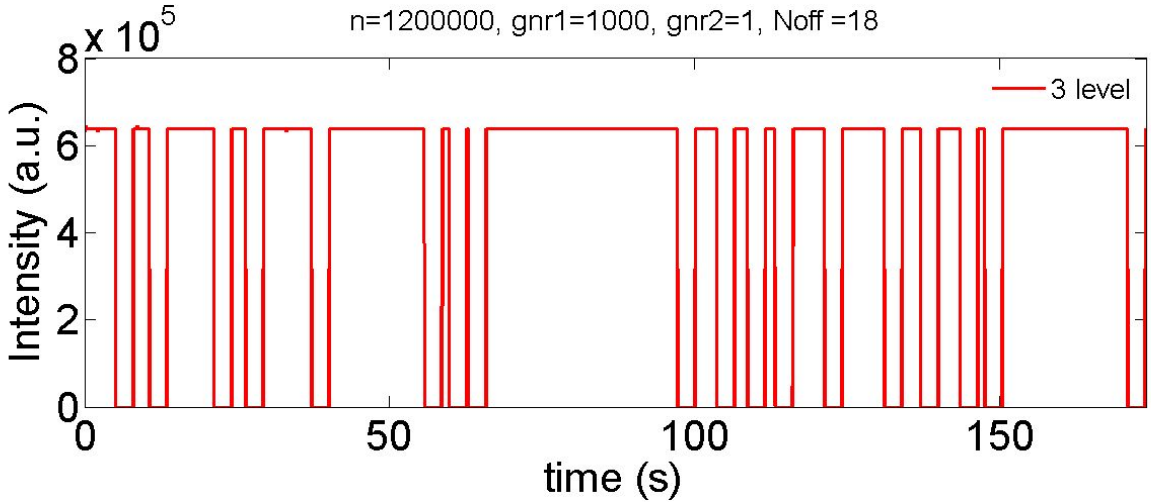


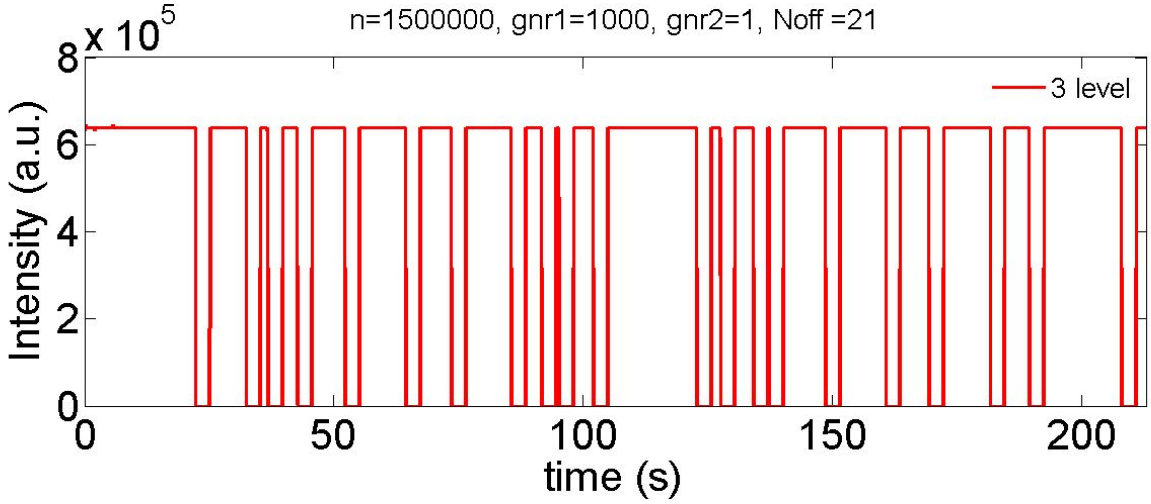


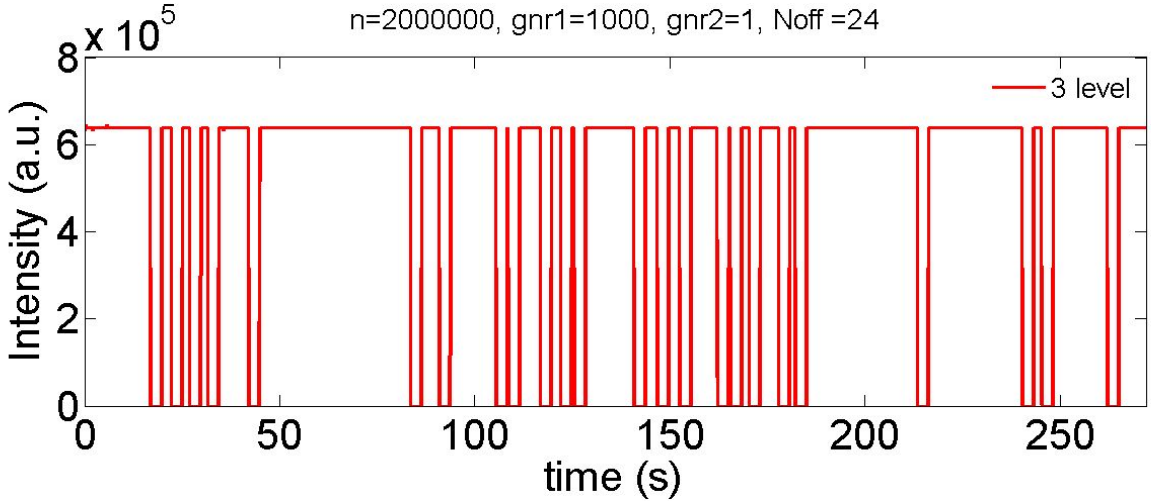

n=700000, gnr1=1000, gnr2=1, Noff =7
x 10^5
Intensity (a.u.)
time (s)
3 level


n=900000, gnr1=1000, gnr2=1, Noff =10
x 10^5
Intensity (a.u.)
time (s)
3 level


n=1000000, gnr1=1000, gnr2=1, Noff =13
x 10^5
Intensity (a.u.)
time (s)
3 level


n=1200000, gnr1=1000, gnr2=1, Noff =18
x 10^5
Intensity (a.u.)
time (s)
3 level


n=1500000, gnr1=1000, gnr2=1, Noff =21
x 10^5
Intensity (a.u.)
time (s)
3 level


n=2000000, gnr1=1000, gnr2=1, Noff =24
x 10^5
Intensity (a.u.)
time (s)
3 level