example-trilinear

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1 QuTiP example: Trilinear Oscillator Coupling

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For more information about QuTiP see http://qutip.org

```
In [1]: %pylab inline
```

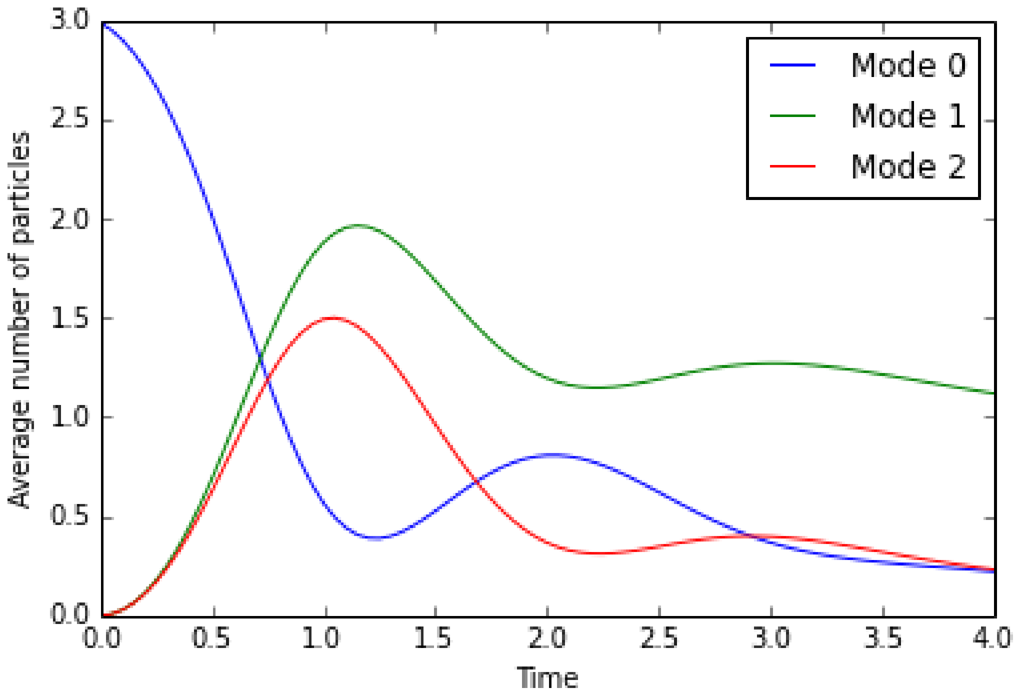
```
Populating the interactive namespace from numpy and matplotlib
```

```
In [2]: from qutip import *
        import time
```

```
In [3]: #number of states for each mode
        N0=8
        N1=8
        N2=8
        K=1.0
        #damping rates
        gamma0=0.1
        gamma1=0.1
        gamma2=0.4
        alpha=sqrt(3)#initial coherent state param for mode 0
        epsilon=0.5j #sqeezing parameter
        tfinal=4.0
        dt=0.05
        tlist=arange(0.0,tfinal+dt,dt)
        taulist=K*tlist #non-dimensional times
        ntraj=100#number of trajectories
        #define operators
        a0=tensor(destroy(N0),qeye(N1),qeye(N2))
        a1=tensor(qeye(N0),destroy(N1),qeye(N2))
        a2=tensor(qeye(N0),qeye(N1),destroy(N2))
        #number operators for each mode
        num0=a0.dag()*a0
        num1=a1.dag()*a1
        num2=a2.dag()*a2
        #dissipative operators for zero-temp. baths
        C0=sqrt(2.0*gamma0)*a0
        C1=sqrt(2.0*gamma1)*a1
        C2=sqrt(2.0*gamma2)*a2
        #initial state: coherent mode 0 & vacuum for modes #1 & #2
        vacuum=tensor(basis(N0,0),basis(N1,0),basis(N2,0))
        D=(alpha*a0.dag()-conj(alpha)*a0).expm()
        psi0=D*vacuum
        #trilinear Hamiltonian
        H=1j*K*(a0*a1.dag()*a2.dag()-a0.dag()*a1*a2)
        #run Monte-Carlo
        start_time=time.time()
        #avg=mcsolve(H,psi0,taulist,ntraj,[C0,C1,C2],[num0,num1,num2])
        output=mesolve(H,psi0,taulist,[C0,C1,C2],[num0,num1,num2])
        avg=output.expect
        finish_time=time.time()
        print('time elapsed = ',finish_time-start_time)
```

```
time elapsed =  16.37485694885254
```

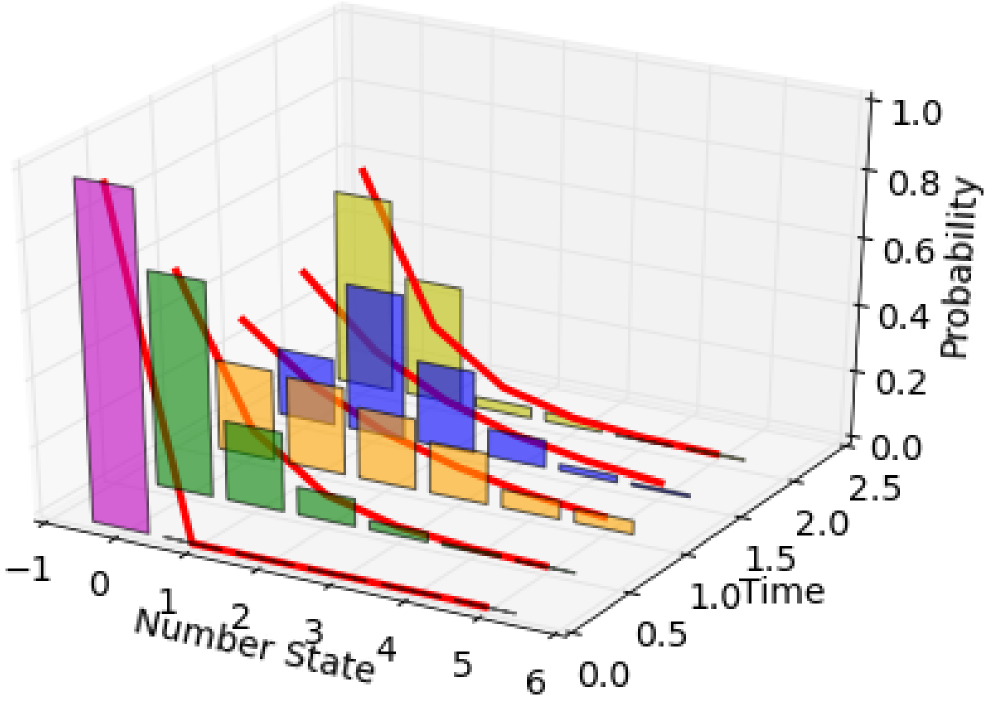
```
In [4]: #plot expectation value for photon number in each mode
        plot(taulist,avg[0],taulist,avg[1],taulist,avg[2])
        xlabel("Time")
        ylabel("Average number of particles")
        legend(('Mode 0', 'Mode 1','Mode 2'));
```



1.1 Deviation form thermal

```
In [5]: from qutip import *
        from pylab import *
        import time
        from mpl_toolkits.mplot3d import Axes3D
        from matplotlib import cm
        #number of states for each mode
        N0=6
        N1=6
        N2=6

        #define operators
        a0=tensor(destroy(N0),qeye(N1),qeye(N2))
        a1=tensor(qeye(N0),destroy(N1),qeye(N2))
        a2=tensor(qeye(N0),qeye(N1),destroy(N2))

        #number operators for each mode
        num0=a0.dag()*a0
        num1=a1.dag()*a1
        num2=a2.dag()*a2

        #initial state: coherent mode 0 & vacuum for modes #1 & #2
        alpha=sqrt(2)#initial coherent state param for mode 0
        initial=tensor(coherent(N0,alpha),basis(N1,0),basis(N2,0))
        psi0=initial

        #trilinear Hamiltonian
        H=1.0j*(a0*a1.dag()*a2.dag()-a0.dag()*a1*a2)


        #run Monte-Carlo
        tlist=linspace(0,2.5,50)
        output=mcsolve(H,psi0,tlist,[],[],1)

        mode1=[ptrace(k,1) for k in output.states]
        diags1=[real(k.diag()) for k in mode1]
        num1=[expect(num1,k) for k in output.states]
        thermal=[thermal_dm(N1,k).diag() for k in num1]
```

```
In [6]: colors=[’m’, ’g’,’orange’,’b’, ’y’,’pink’]
        x=range(N1)
        params = {’axes.labelsize’: 14,’text.fontsize’: 14,’legend.fontsize’: 12,
                  ’xtick.labelsize’: 14,’ytick.labelsize’: 14}
        rcParams.update(params)
        fig = plt.figure()
        ax = Axes3D(fig)
        for j in range(5):
            ax.bar(x, diags1[10*j], zs=tlist[10*j], zdir=’y’,color=colors[j],linewidth=1.0,
                   alpha=0.6,align=’center’)
            ax.plot(x,thermal[10*j],zs=tlist[10*j],zdir=’y’,color=’r’,linewidth=3,alpha=1)
        ax.set_zlabel(r’Probability’)
        ax.set_xlabel(r’Number State’)
        ax.set_ylabel(r’Time’)
        ax.set_zlim3d(0, 1);
```



1.2 Software version:

```
In [7]: from qutip.ipynbtools import version_table

        version_table()

Out[7]: <IPython.core.display.HTML at 0x7f474b6cc048>
```