Introduction_QuantumSystem_SpingleSpin

February 24, 2025

1 PyOR Quantum

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1.0.2 Introduction to PyOR Quantum

[1]:
```
SourcePath = '/media/HD2/Vineeth/PostDoc_Simulations/Github/PyOR_V1/Source'
import sys
sys.path.append(SourcePath)

from PythonOnResonance_MagneticResonance import MagneticResonance
from PythonOnResonance_Quantum import QunObj, QuantumLibrary, QuantumSystem

import time
import numpy as np
import matplotlib.pyplot as plt
from matplotlib import rc
%matplotlib ipympl
import sympy as sp
from sympy import *
```

1.0.3 Introduction to Quantum System

[2]:
```
SpinList = {"I": 1/2}

QS = QuantumSystem(SpinList)
QLib = QuantumLibrary()

QS.SpinOperator(PrintDefault=False)
```

[3]:
```
# Spin list
QS.slist
```

[3]:
```
array([0.5])
```

[4]:
```
# Number of spins
QS.Nspins
```

[4]: 1

[5]:
```
# Spin dictionary
QS.SpinDic
```

[5]: ['I']

[6]:
```
# Dimension of each individual spin system
QS.Sdim
```

[6]: array([2])

[7]:
```
QS.Vdim
```

[7]: 2

[8]:
```
# Dimension of Liouville space
QS.Ldim
```

[8]: 4

1.0.4 Spin operators

[9]:
```
# Ix object
QS.Ix
```

[9]: <PythonOnResonance_Quantum.QunObj at 0x7f6fd395bb00>

[10]:
```
# X component of spin I
QS.Ix.matrix
```

[10]: $\begin{bmatrix} 0 & 0.5 \\ 0.5 & 0 \end{bmatrix}$

[11]:
```
# Identy matrix
QS.Iid.matrix
```

[11]: $\begin{bmatrix} 1.0 & 0 \\ 0 & 1.0 \end{bmatrix}$

1.0.5 Spin operators of sub sysytem

[12]:
```
# X component of I
QS.Ix_sub.matrix
```

[12]: $\begin{bmatrix} 0 & 0.5 \\ 0.5 & 0 \end{bmatrix}$

[13]:
```python
# Identy matrix
QS.Iid_sub.matrix
```

[13]:

$$\begin{bmatrix} 1.0 & 0 \\ 0 & 1.0 \end{bmatrix}$$

1.0.6 Schrödinger Equation

[14]:
```python
# Initial State
vec = QLib.Basis_Ket(2,0)
```

[15]:
```python
vec.matrix
```

[15]:

$$\begin{bmatrix} 1.0 \\ 0 \end{bmatrix}$$

[16]:
```python
# Rotate by 90 deg about X axis
vec = vec.Rotate(90,QS.Ix)
```

[17]:
```python
vec.Round(3).matrix
```

[17]:

$$\begin{bmatrix} 0.707 \\ -0.707i \end{bmatrix}$$

[18]:
```python
# Hamiltonian
Hz = 2.0 * np.pi * 10 * QS.Iz
```

[19]:
```python
Hz.matrix
```

[19]:

$$\begin{bmatrix} 31.4159265358979 & 0 \\ 0 & -31.4159265358979 \end{bmatrix}$$

[20]:
```python
# Evolution
QLib.AcqAQ = 1
QLib.AcqDT = 0.001
t, vect = QLib.Evolve_SE_UProp(vec,Hz)
```

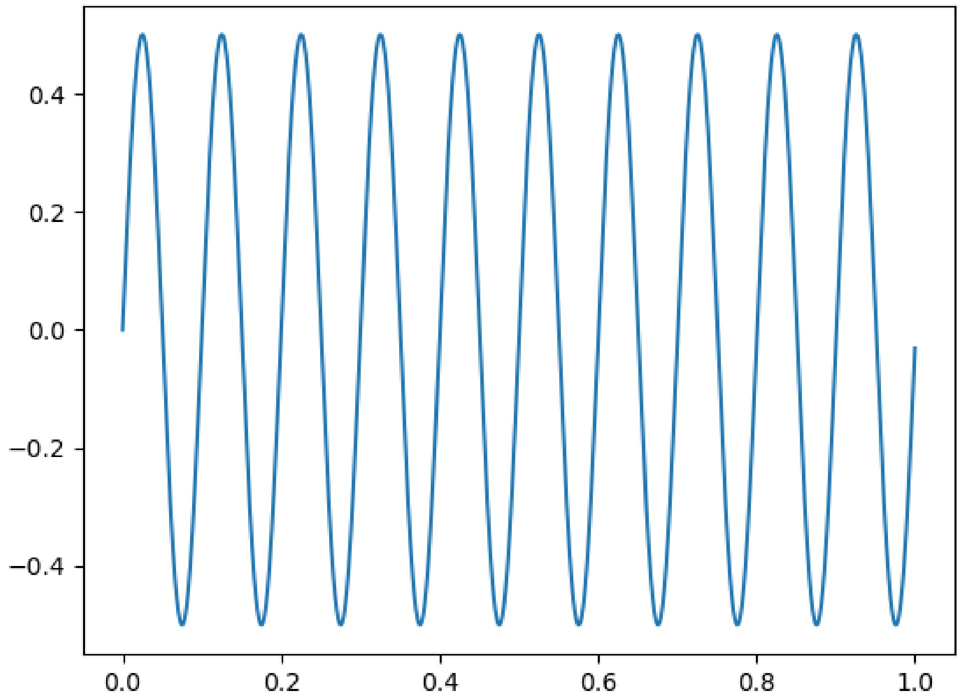
[21]:
```python
# Expectation
t, signal_SE = QLib.Expectation(t,vect,QS.Ix)
```

[22]:
```python
# Plotting
plt.figure(1)
plt.plot(t,signal_SE)
```

```
/opt/anaconda3/lib/python3.12/site-packages/matplotlib/cbook.py:1762:
ComplexWarning: Casting complex values to real discards the imaginary part
  return math.isfinite(val)
/opt/anaconda3/lib/python3.12/site-packages/matplotlib/cbook.py:1398:
```

```
ComplexWarning: Casting complex values to real discards the imaginary part
  return np.asarray(x, float)
```

[22]: `[<matplotlib.lines.Line2D at 0x7f6fcab9d940>]`



1.0.7 Liouville Equation : Hilbert Space

[23]:
```
# Initial density matrix
rho = QS.Iz
```

[24]:
```
rho.matrix
```

[24]: $\begin{bmatrix} 0.5 & 0 \\ 0 & -0.5 \end{bmatrix}$

[25]:
```
# Rotate about x axis by 90 deg
rho = rho.Rotate(90,QS.Ix)
```

[26]:
```
rho.matrix
```

[26]: $\begin{bmatrix} 0 & 0.5i \\ -0.5i & 0 \end{bmatrix}$

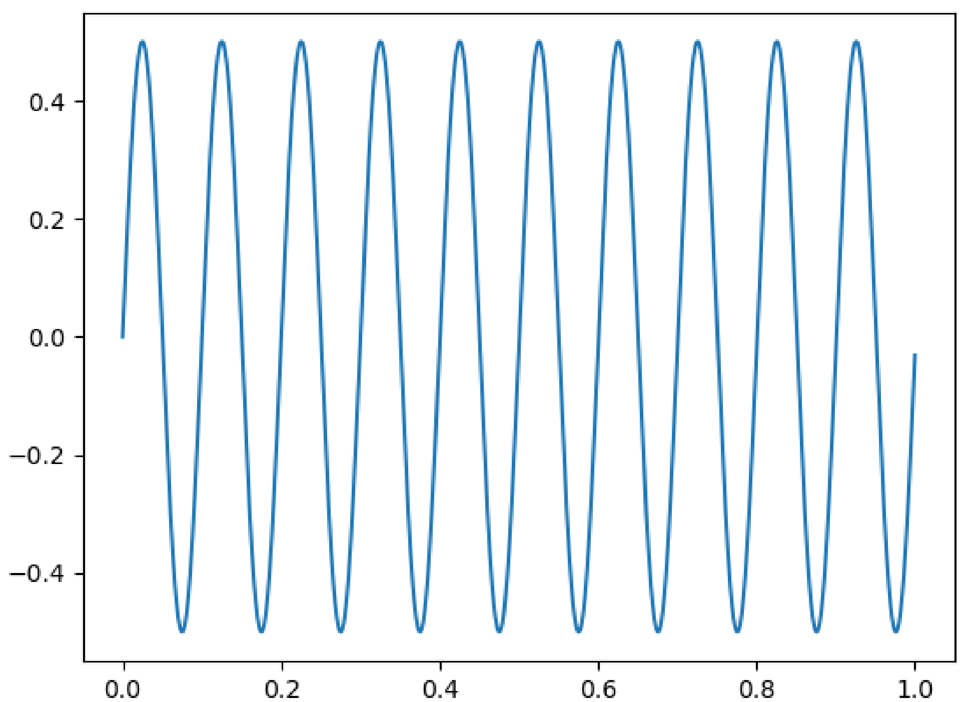
[27]:
```
# Hamiltonian
Hz = 2.0 * np.pi * 10 * QS.Iz
```

[28]:
```
# Evolution
QLib.AcqAQ = 1
QLib.AcqDT = 0.001
t, rhot = QLib.Evolve_Hilbert_UProp(rho,Hz)
```

[29]:
```
# Expectation
t, signal_Hi = QLib.Expectation(t,rhot,QS.Ix)
```

[30]:
```
# Plotting
plt.figure(2)
plt.plot(t,signal_Hi)
```

[30]:
```
[<matplotlib.lines.Line2D at 0x7f6fc8d73bc0>]
```



1.0.8 Liouville Equation : Liouville Space

[31]:
```
# Initial density matrix
rhoL = QS.Iz
```

[32]:
```
rhoL.matrix
```

[32]:

$$\begin{bmatrix} 0.5 & 0 \\ 0 & -0.5 \end{bmatrix}$$

[33]:
```
# Vectorize
QLib.RowColOrder = 'C' # Vectorize by row
Lrho = QLib.DMToVec(rhoL)
```

[34]:
```
Lrho.matrix
```

[34]:

$$\begin{bmatrix} 0.5 \\ 0 \\ 0 \\ -0.5 \end{bmatrix}$$

[35]:
```
# Rotate by 90 deg about X axis
Lrho = Lrho.Rotate(90,QLib.CommutationSuperoperator(QS.Ix))
```

[36]:
```
Lrho.matrix
```

[36]:

$$\begin{bmatrix} 0 \\ 0.5i \\ -0.5i \\ 0 \end{bmatrix}$$

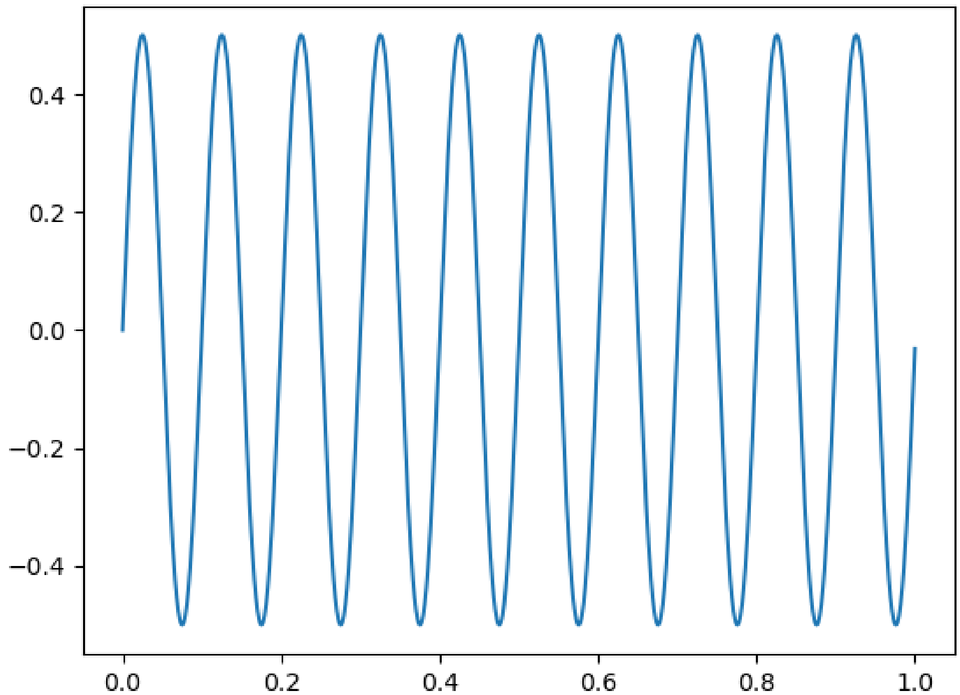
[37]:
```
# Hamiltonian
Hz = 2.0 * np.pi * 10 * QS.Iz
HzL = QLib.CommutationSuperoperator(Hz)
```

[38]:
```
# Evolution
QLib.AcqAQ = 1
QLib.AcqDT = 0.001
t, Lrhot = QLib.Evolve_Liouville_UProp(Lrho,HzL)
```

[39]:
```
# Expectation
t, signal_Li = QLib.Expectation(t,Lrhot,QLib.DMToVec(QS.Ix).Adjoint())
```

[40]:
```
# Plotting
plt.figure(3)
plt.plot(t,signal_Li)
```

[40]:
```
[<matplotlib.lines.Line2D at 0x7f6fc851aba0>]
```


0.4
0.2
0.0
−0.2
−0.4
0.0
0.2
0.4
0.6
0.8
1.0