CNB_N1600_master_eq

August 8, 2017

```
In [57]: from datetime import datetime
         import numpy as np
         import matplotlib.pyplot as plt
         import pandas as pd
         import seaborn as sns

         from scipy.stats import poisson

         from qutip import *
         import laser
         import cnb
         import entropy_utils
```

```
In [58]: %matplotlib inline
         %reload_ext autoreload
         %autoreload 1
         %aimport laser, cnb, entropy_utils
```

```
In [59]: from IPython.display import set_matplotlib_formats
         set_matplotlib_formats('pdf', 'png')
```

0.1 An example for CNB I and CNB II

```
In [60]: # CNB I
         N = 1600 # number of trapped bosons
         kappa = 1.2e-7 # rate constant
         TTc = 0.94 # T/T_c, where T_c is the critical temperature

         init_psi = fock(N + 1, 0) # initial state

         cnb1 = cnb.CNB(N, kappa, TTc, eta=0) # CNB I
         cnb2 = cnb.CNB(N, kappa, TTc, eta=0.368) # CNB II
```

```
In [61]: t_list = np.linspace(0, 600000, 1001)

         print(str(datetime.now()))
         cnb1.pn_evolve(init_psi, t_list1)
         print(str(datetime.now()))
```

```
        cnb2.pn_evolve(init_psi, t_list1)
        print(str(datetime.now()))
```

```
2017-08-08 14:16:38.376401
2017-08-08 14:20:33.785598
2017-08-08 14:23:21.186122
```

```
In [105]: n_dict = {'$\kappa t$': t_list * kappa}
          entr_dict = {'$\kappa t$': t_list * kappa}
          pn_dict = {'n': np.arange(N + 1)}

          n_dict['CNB I'] = cnb1.get_ns()
          n_dict['CNB II'] = cnb2.get_ns()
          entr_dict['CNB I'] = cnb1.get_entrs()
          entr_dict['CNB II'] = cnb2.get_entrs()
          pn_dict['CNB I'] = cnb1.get_pns()[-1]
          pn_dict['CNB II'] = cnb2.get_pns()[-1]

          n_df = pd.DataFrame(n_dict, columns=n_dict.keys())
          entr_df = pd.DataFrame(entr_dict, columns=entr_dict.keys())
          pn_df = pd.DataFrame(pn_dict, columns=pn_dict.keys())
```

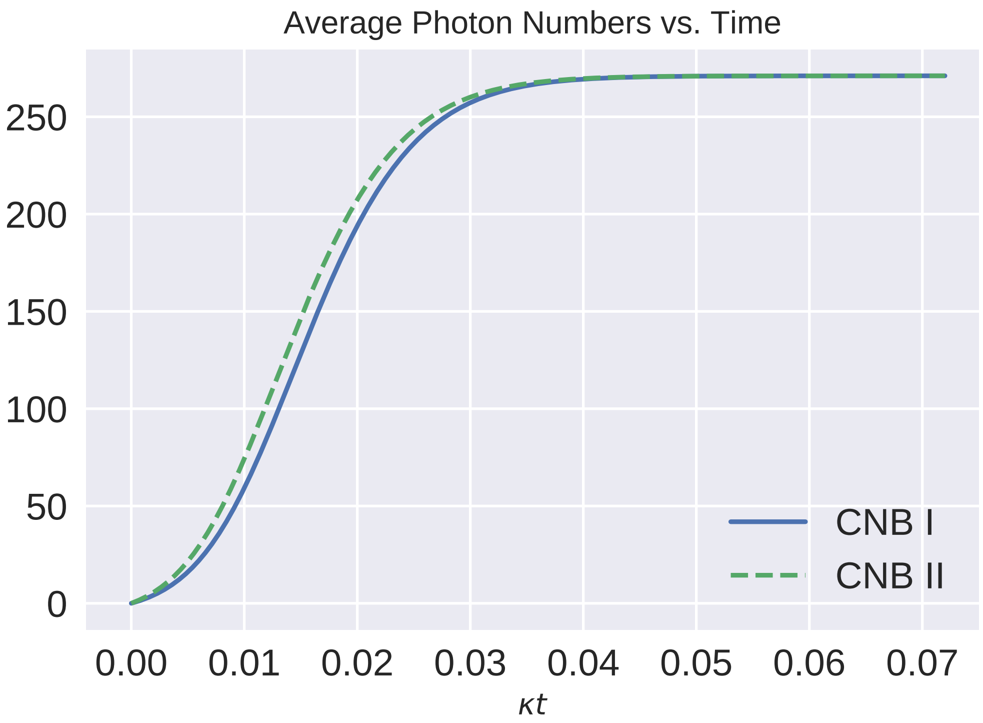
0.1.1 Setup

- Number of Bosons: N = 1600
- Temperature: T/T_c = 0.94
- Rate Constant: kappa = 1.2e-7
- Cross Excitation Parameters for CNB II: eta = 0.368

0.1.2 Results

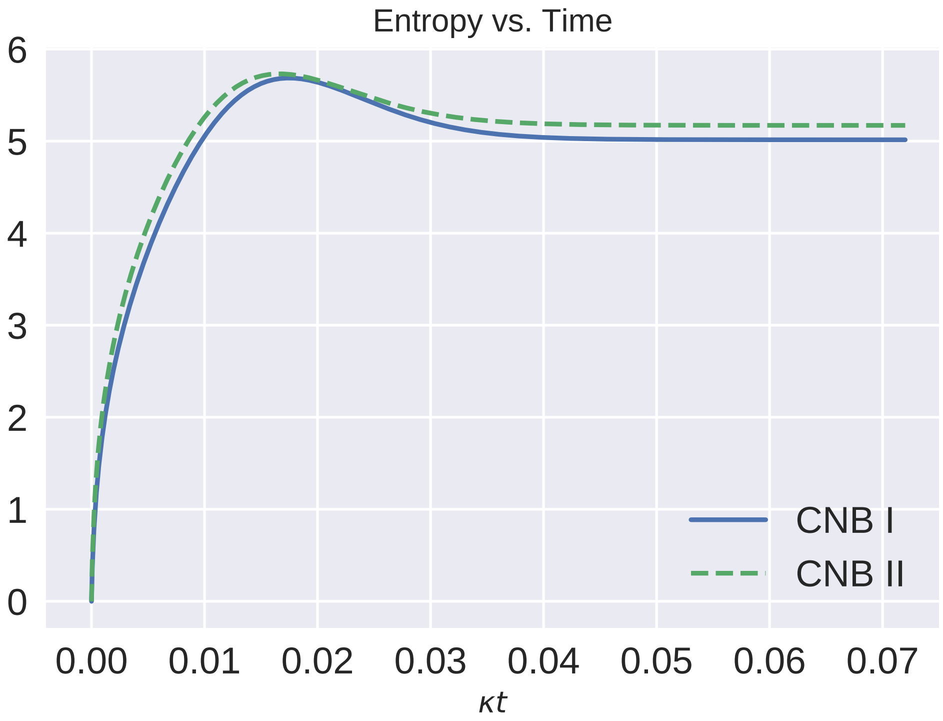
Avergae Boson Numbers vs. Time

```
In [117]: n_df.plot(x='$\kappa t$', xlim=(-0.004, 0.075),
                    figsize=(6, 4), fontsize=14, style=['-', '--'])
          plt.legend(fontsize=14, loc=4)
          plt.title("Average Boson Numbers vs. Time")

Out[117]: <matplotlib.text.Text at 0x7f611a6bac18>
```



Entropy vs. Time

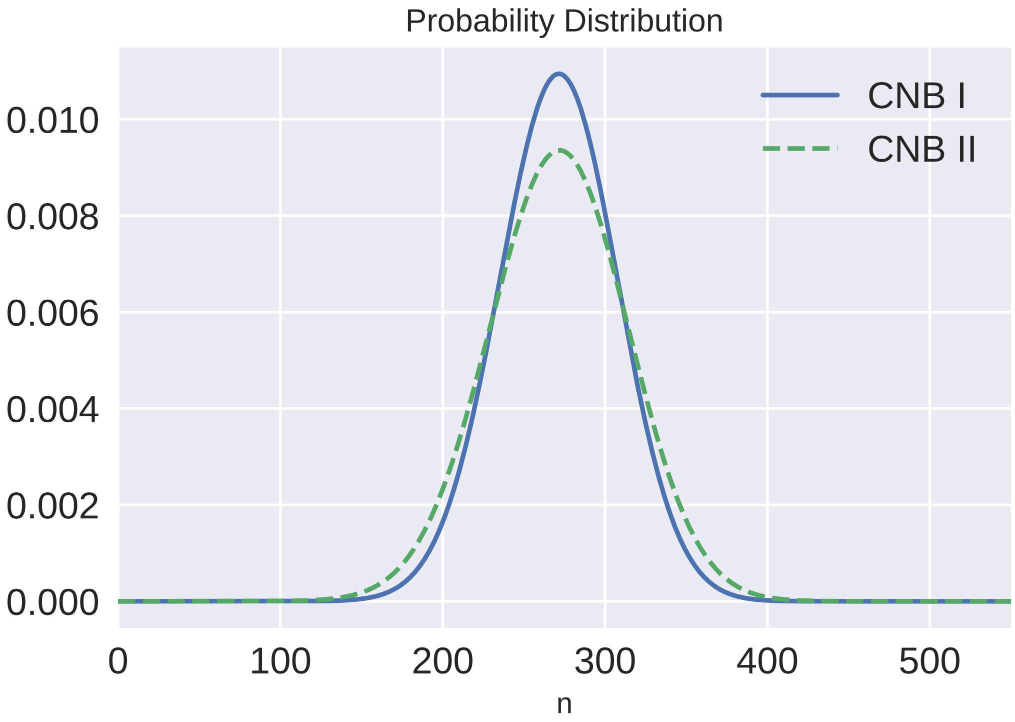
```
In [118]: entr_df.plot(x='$\kappa t$', xlim=(-0.004, 0.075),
                       figsize=(6, 4), fontsize=14, style=['-', '--'])
          plt.legend(fontsize=14, loc=4)
          plt.title("Entropy vs. Time")

Out[118]: <matplotlib.text.Text at 0x7f611a629ac8>
```



Probability Distribution of Stable State

```
In [120]: pn_df.plot(x='n', xlim=(0, 550),
                     figsize=(6, 4), fontsize=14, style=['-', '--'])
          plt.legend(fontsize=14, loc=1)
          plt.title("Probability Distribution")
```

```
Out[120]: <matplotlib.text.Text at 0x7f611a4a6198>
```


Probability Distribution
0.010
0.008
0.006
0.004
0.002
0.000
0
100
200
300
400
500
n
CNB I
CNB II