在这里就采用周期边界的IsingModel进行模拟（电脑跑不了那么高性能服务）

然后给的demo老师您确定可以跑吗？

为什么我复制下来逐单元格运行结果发现全是报错？ 标准运行也运行不了啊

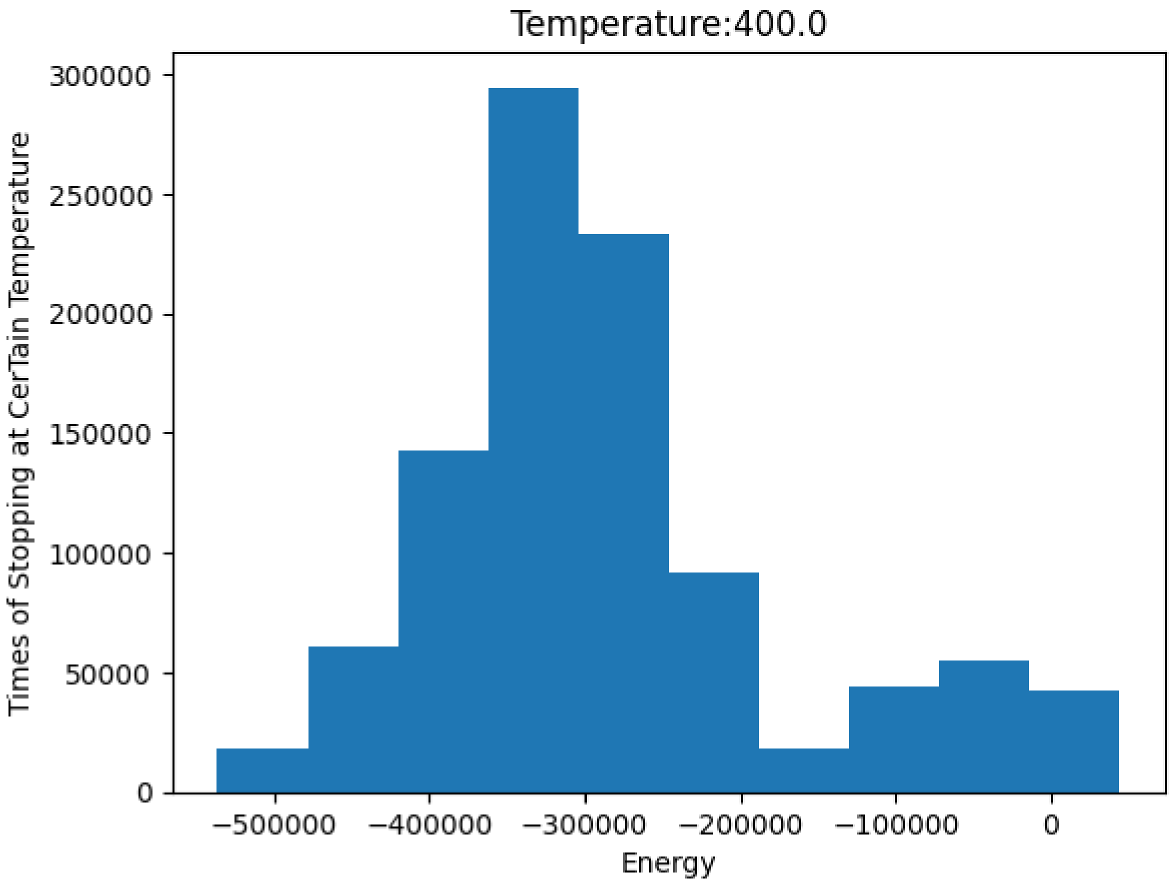
In [6]:

```
import numpy as np
import matplotlib.pyplot as plt
import random
import math
```

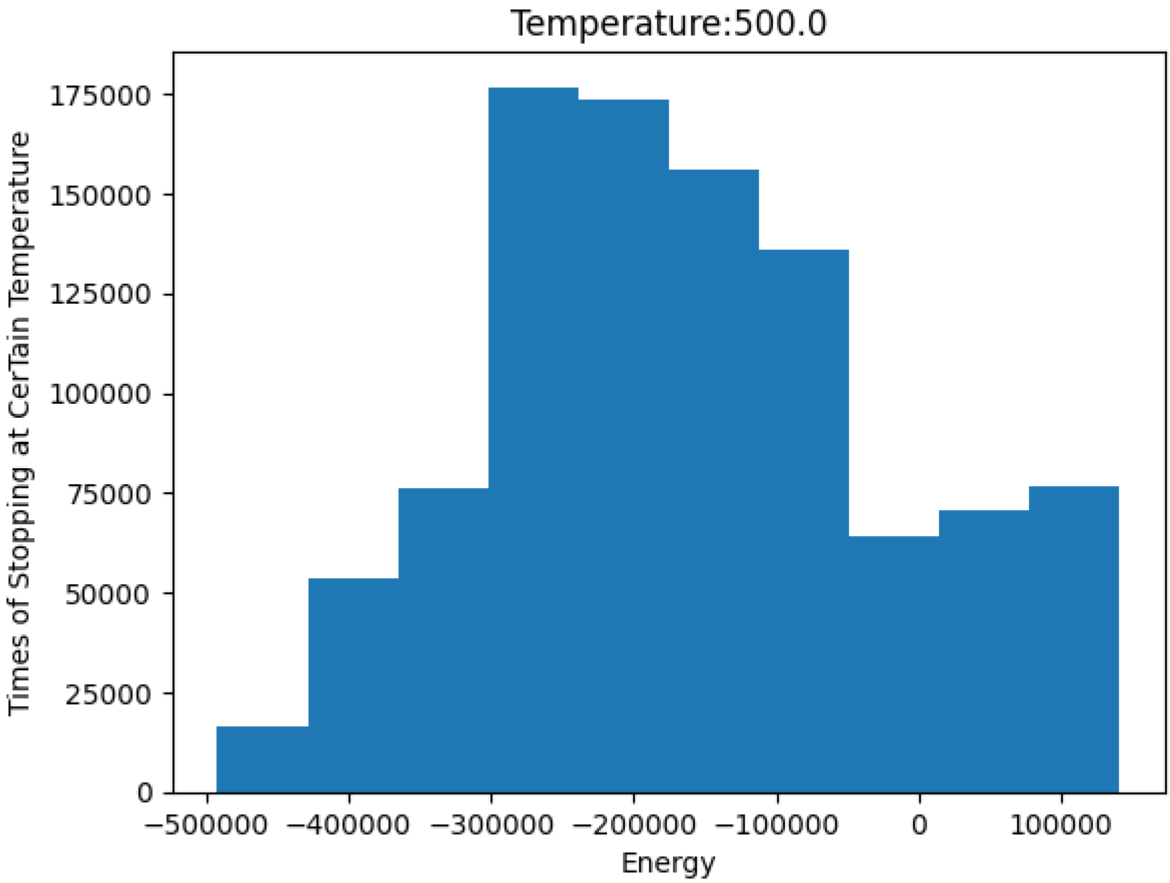
In [9]:

```
def S_near(i,j,Energy):
    return Energy
def IsingModel(Length,height,T,Start_Times ,Trial_times):
    beta=1/T
    M=0
    data=[]
    s=2*np.random.randint(0,1,(Length,height))-1
    Es=-np.sum(s[:,0:height-1]*s[:,1:height])-np.sum(s[0:Length-1,:]*s[1:Length,:])
    for t in range(Start_Times+Trial_times):
        location=[random.randint(0,Length-1),random.randint(0,height-1)]
        snew=s
        snew[location[0],location[1]]=-snew[location[0],location[1]]
        Ey=-np.sum(snew[:,0:height-1]*snew[:,1:height])-np.sum(snew[0:Length-1,:]*
        h=min(1,np.exp(-(Ey-Es)*beta))
        u=random.random()
        if u<h:
            s=snew
        if t>=Start_Times:
            M+=np.sum(s)
            data.append(M)
    M/=Trial_times
    print("Average:",M)
    plt.hist(data)
    plt.xlabel("Energy")
    plt.ylabel("Times of Stopping at CerTain Temperature")
    plt.title("Temperature:"+str(T))
    plt.show()
    return M
Tlist=np.linspace(400,2000,17).tolist()
for T in Tlist:
    IsingModel(32,16,T,1000000,1000000)
```

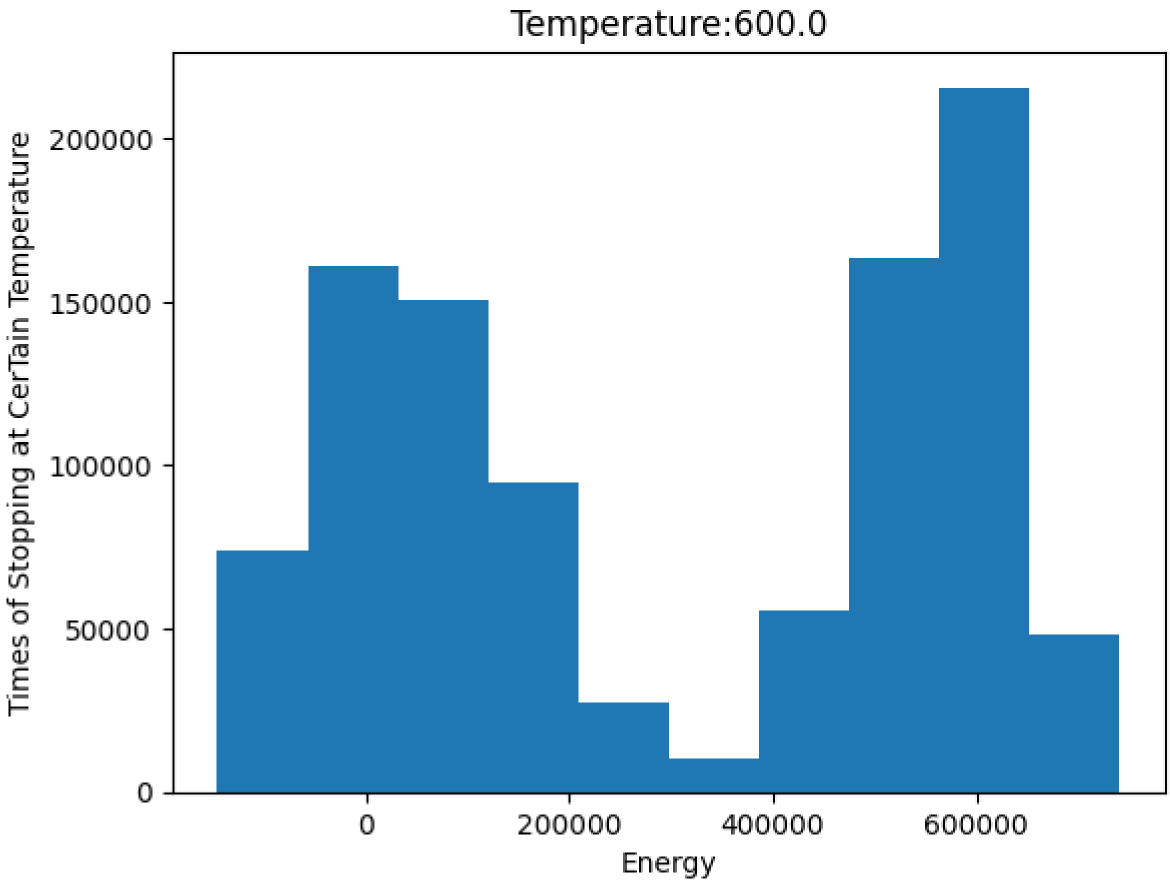
```
Average: -0.517504
```



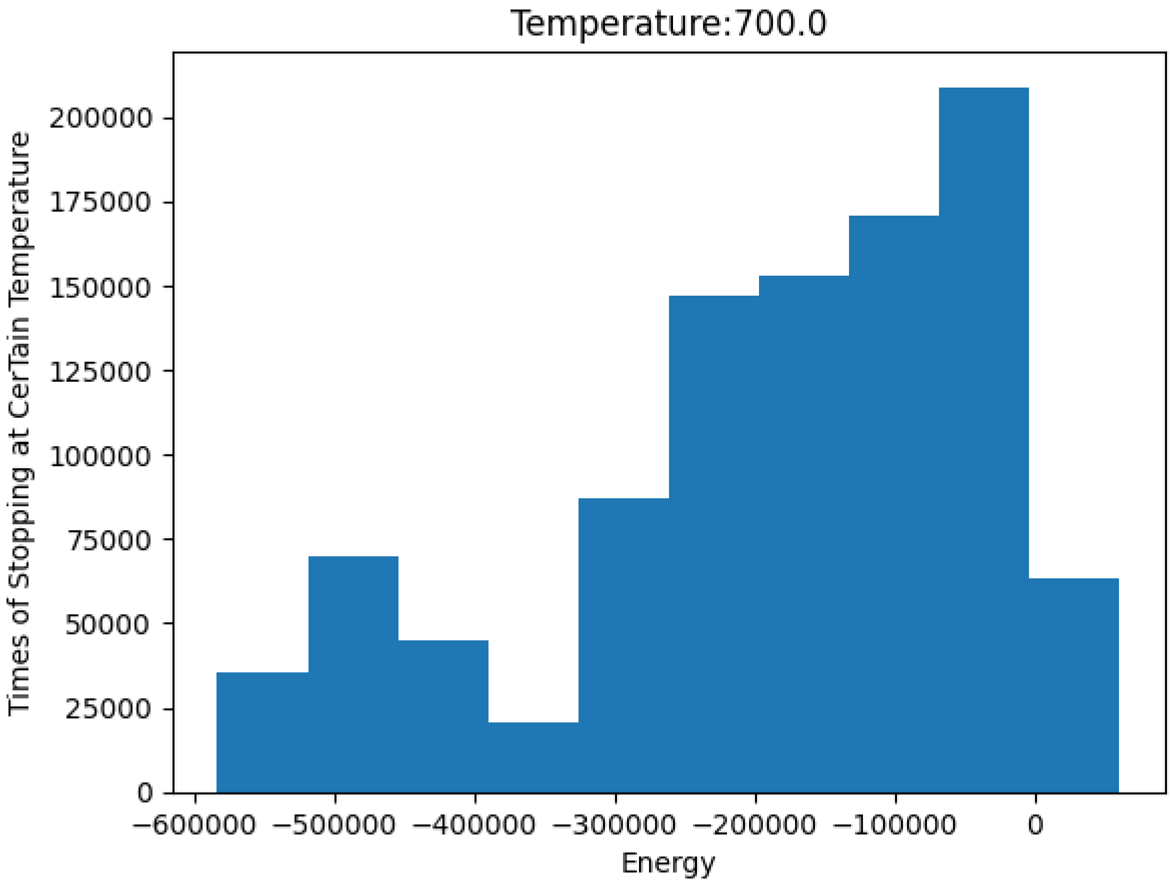
```
Average: -0.43456
```



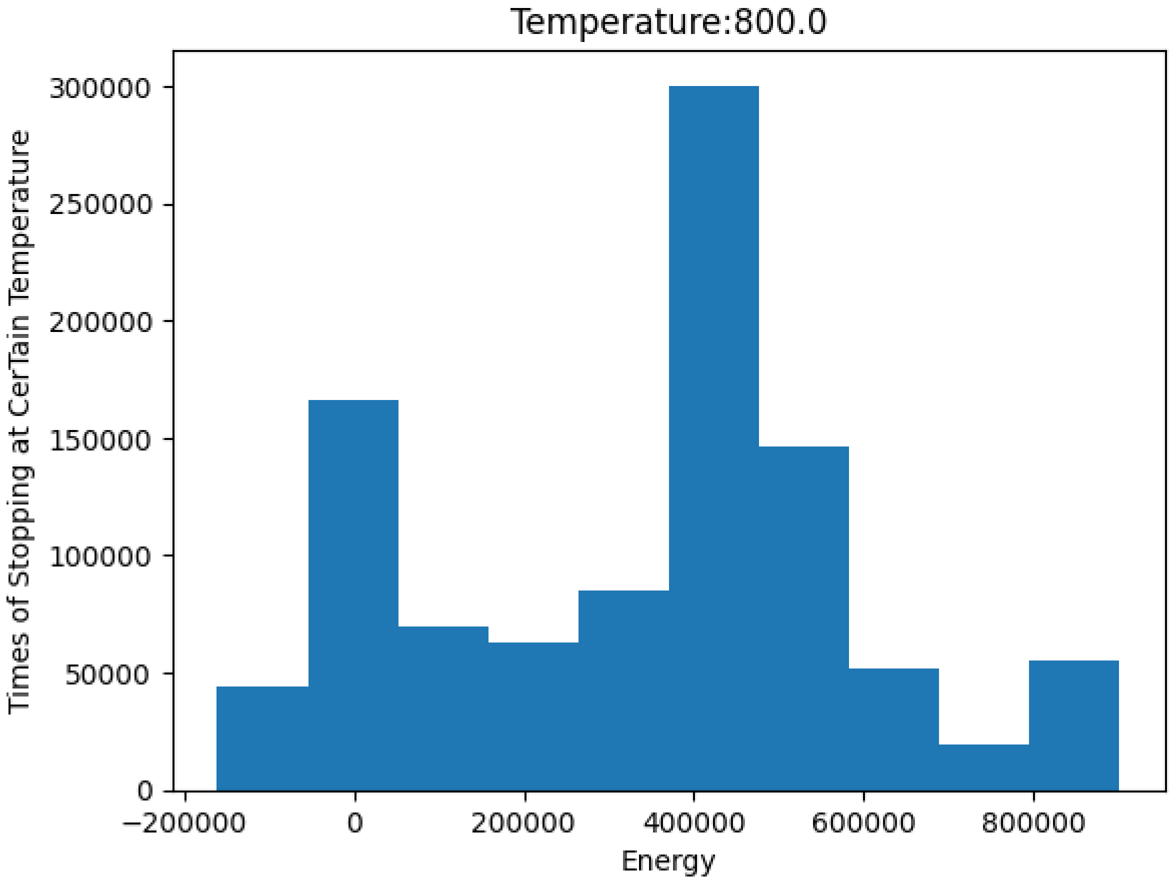
```
Average: 0.36008
```



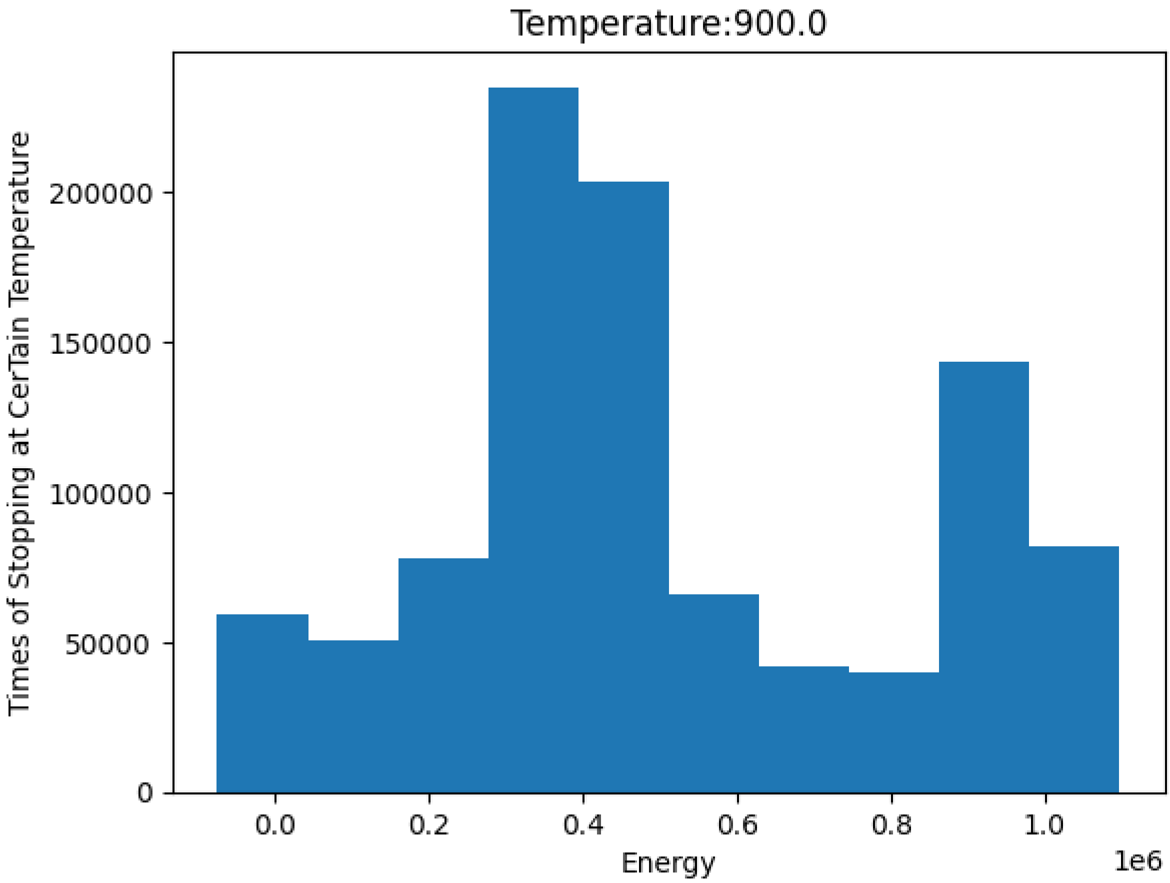
```
Average: -0.424092
```



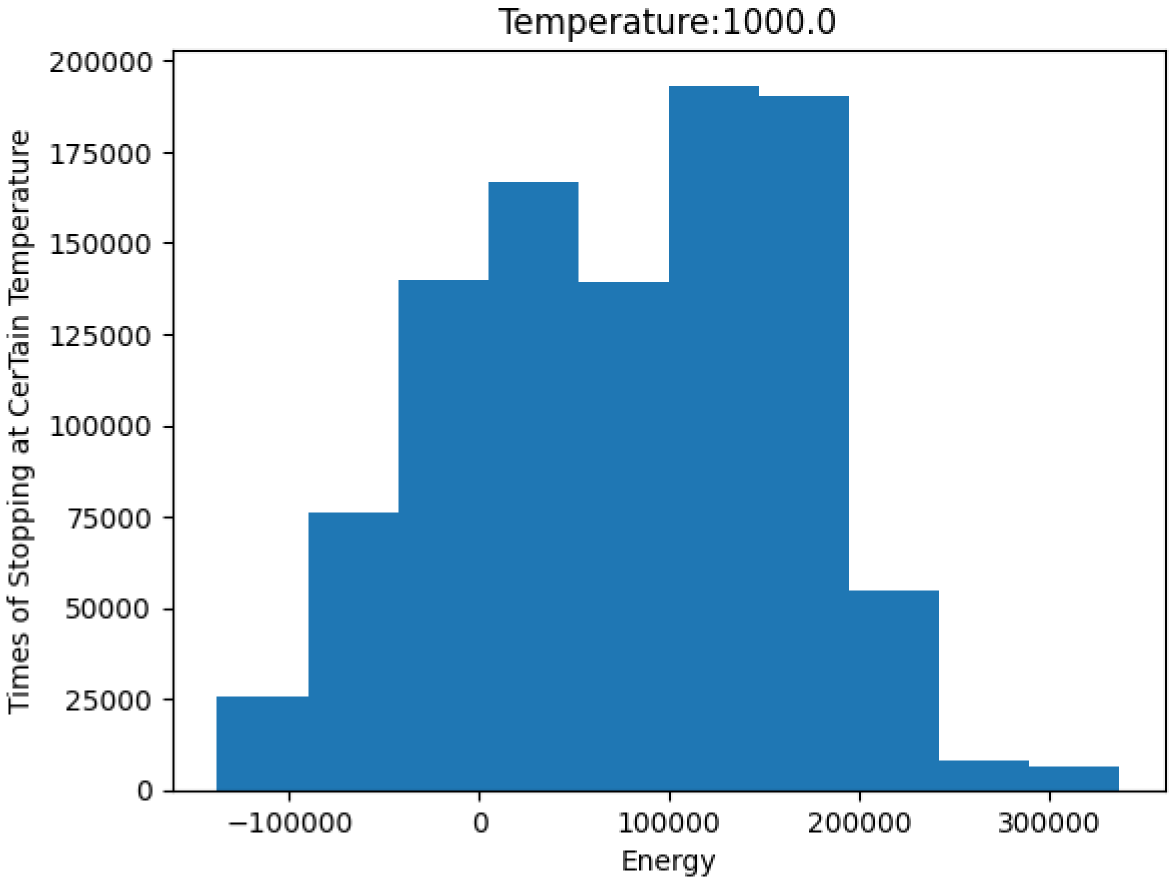
```
Average: 0.83252
```



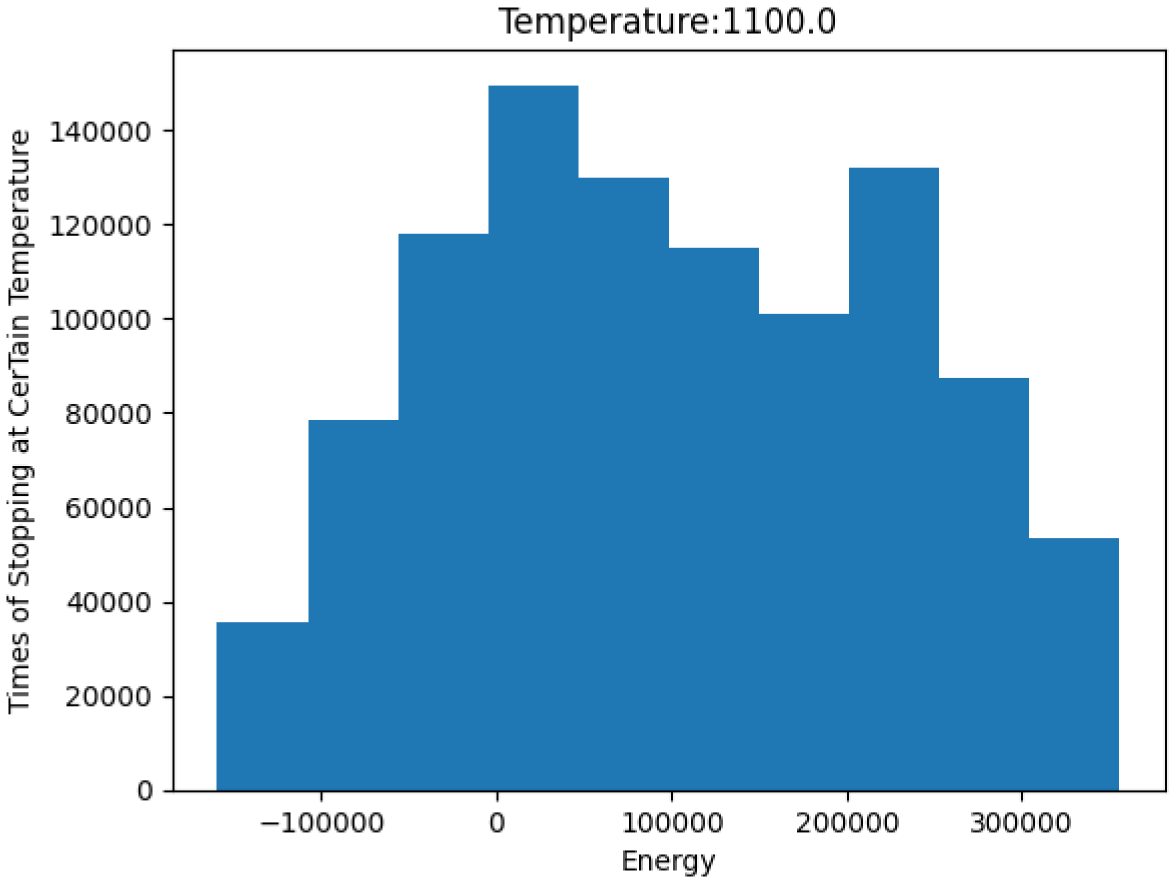
```
Average: 0.943212
```



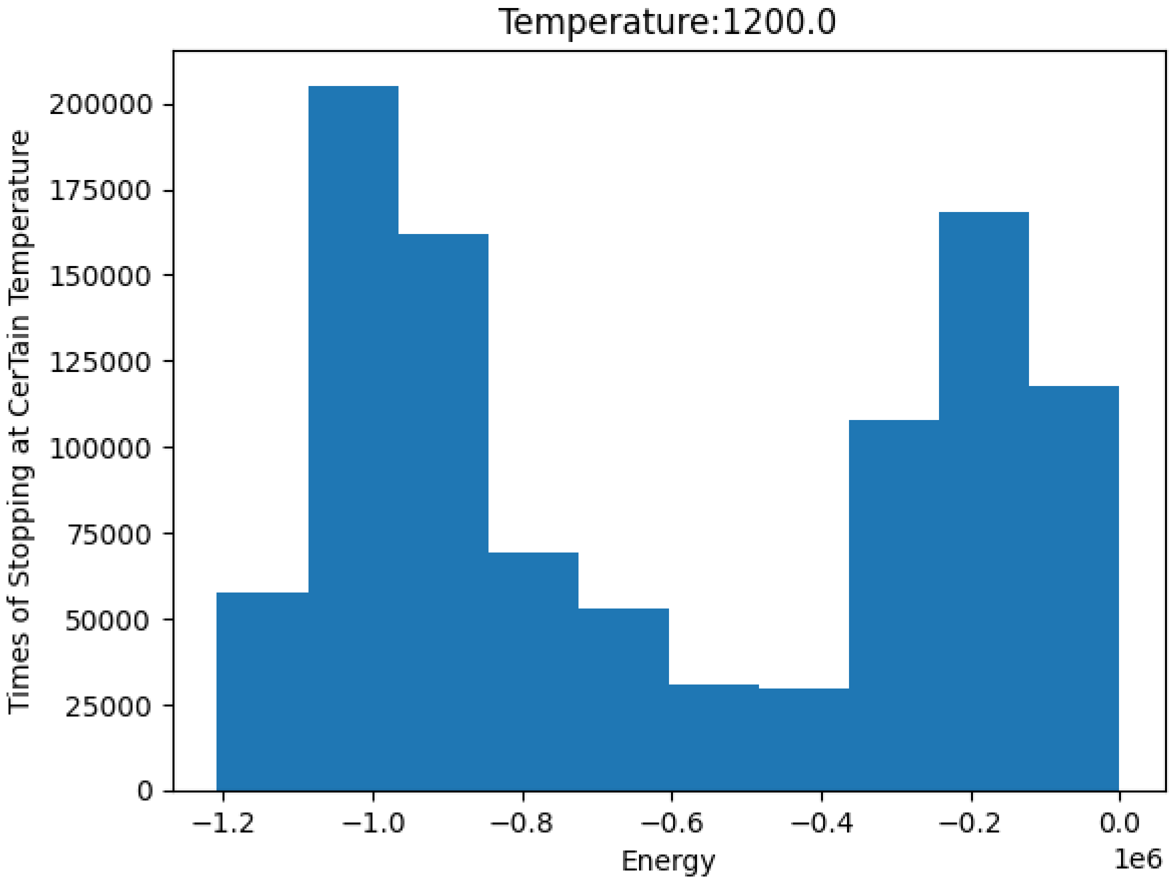
```
Average: 0.022124
```



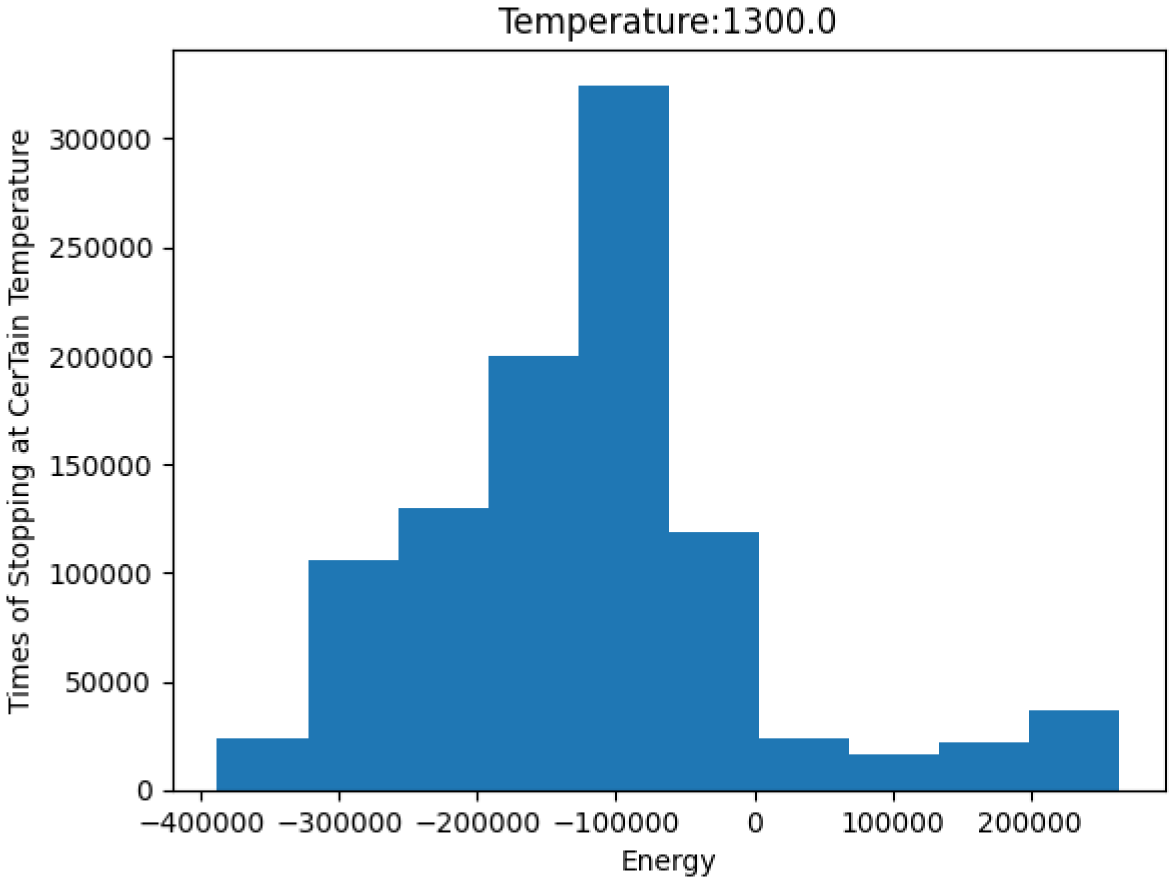
```
Average: -0.031836
```



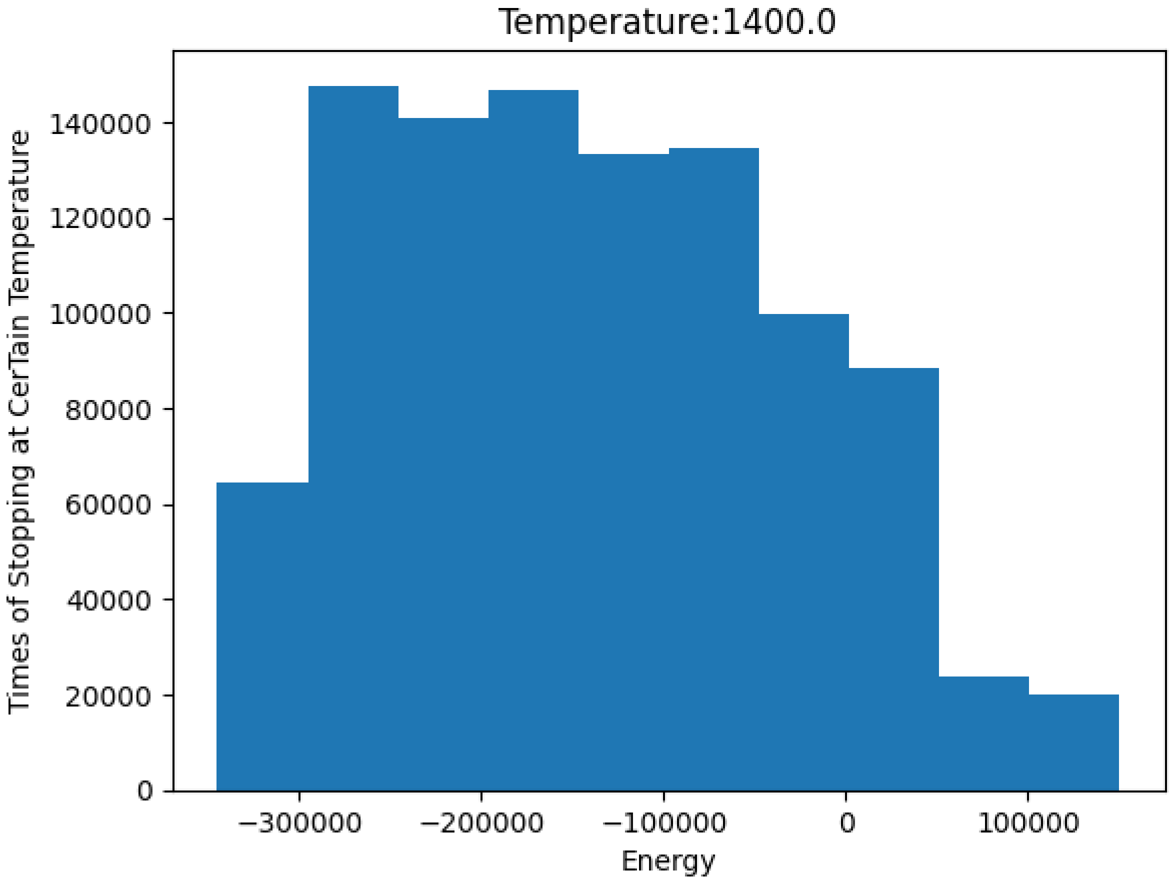
```
Average: -1.139604
```



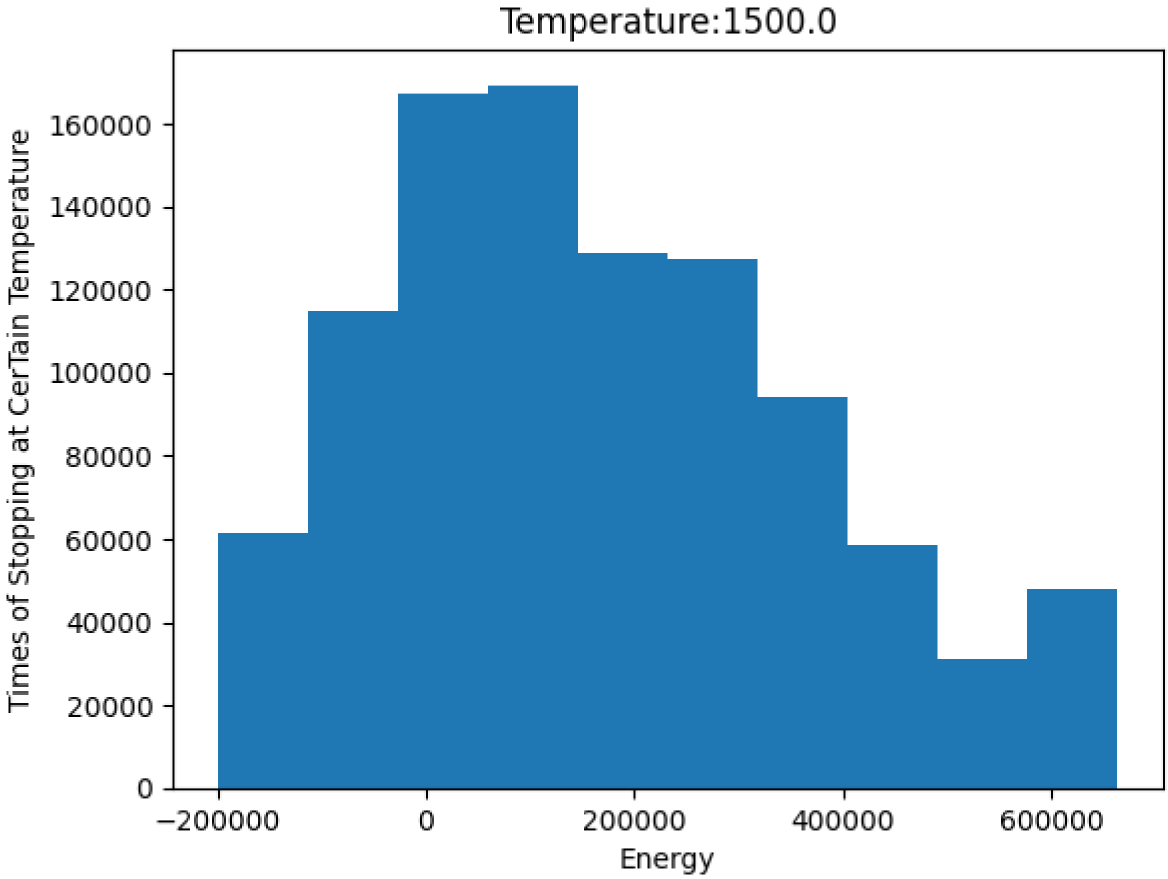
```
Average: 0.165532
```



```
Average: -0.092372
```



```
Average: 0.084424
```



```
Average: 0.043108
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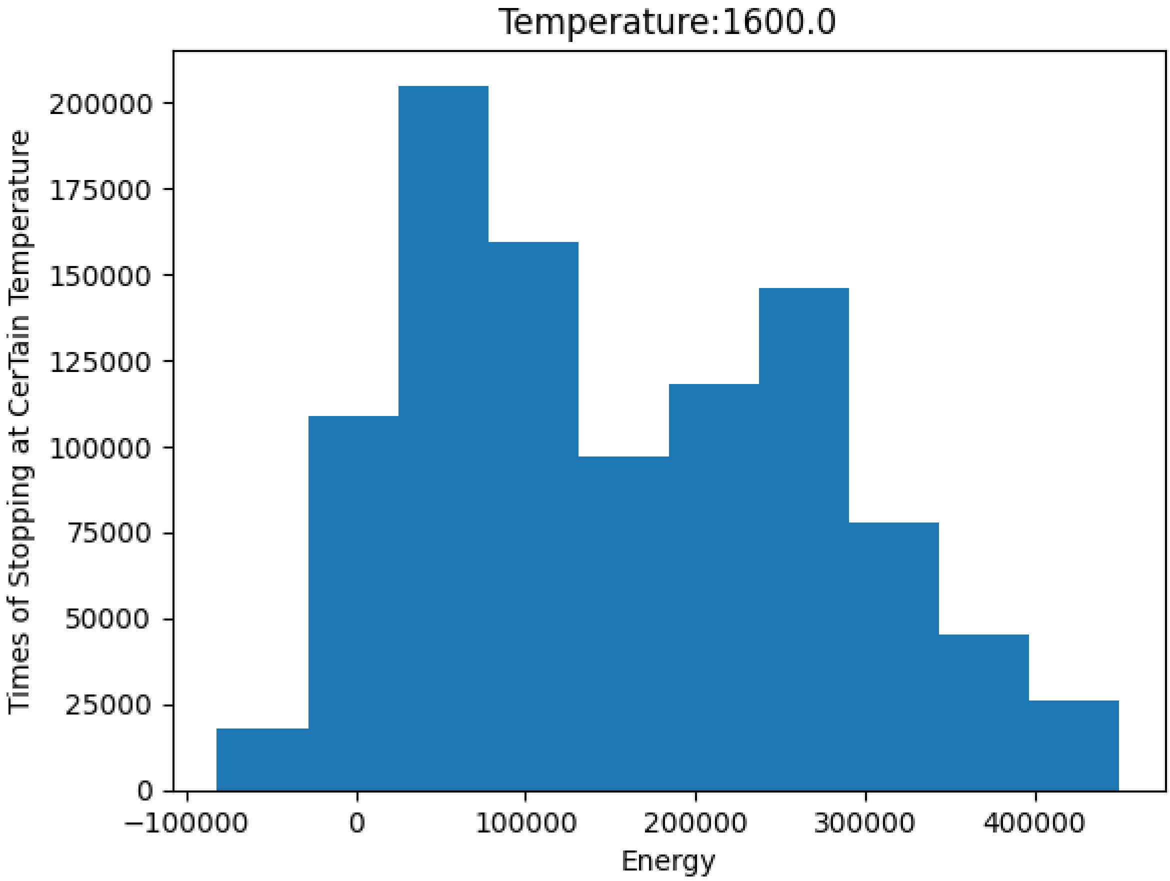
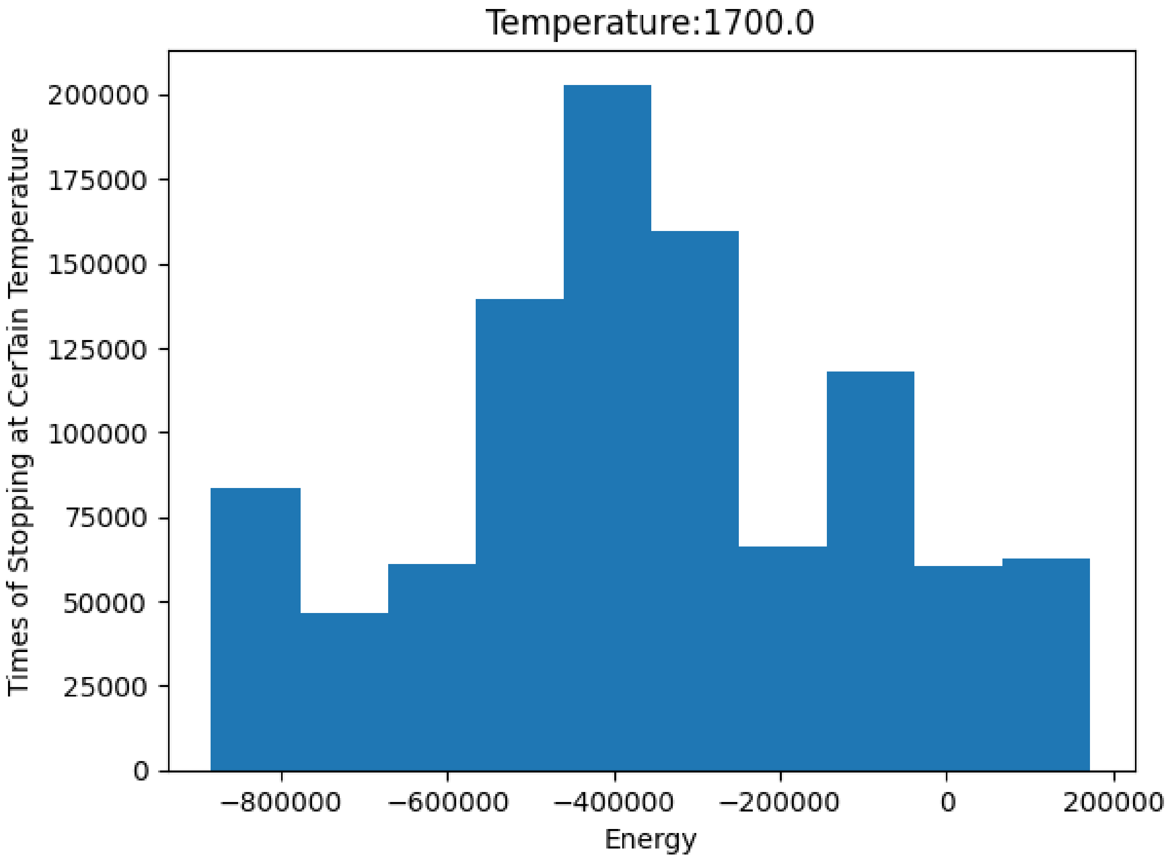
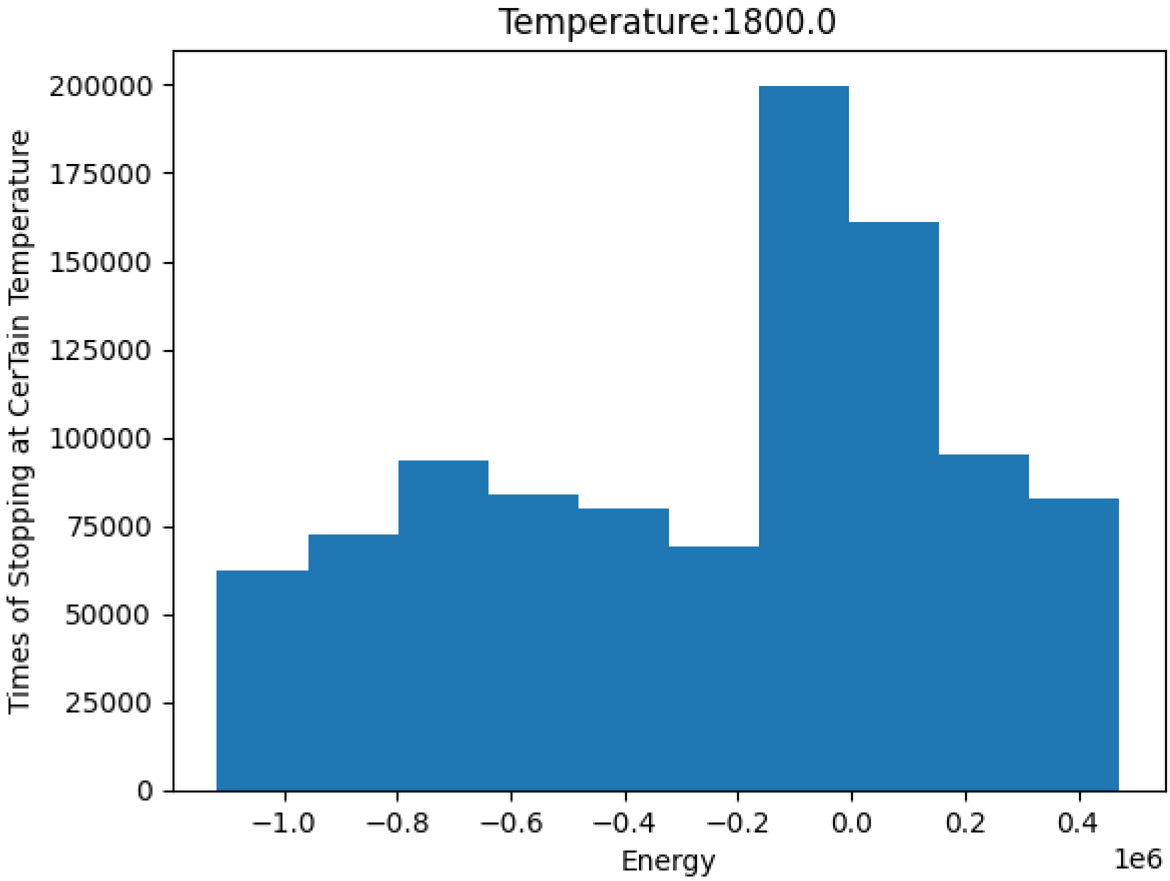


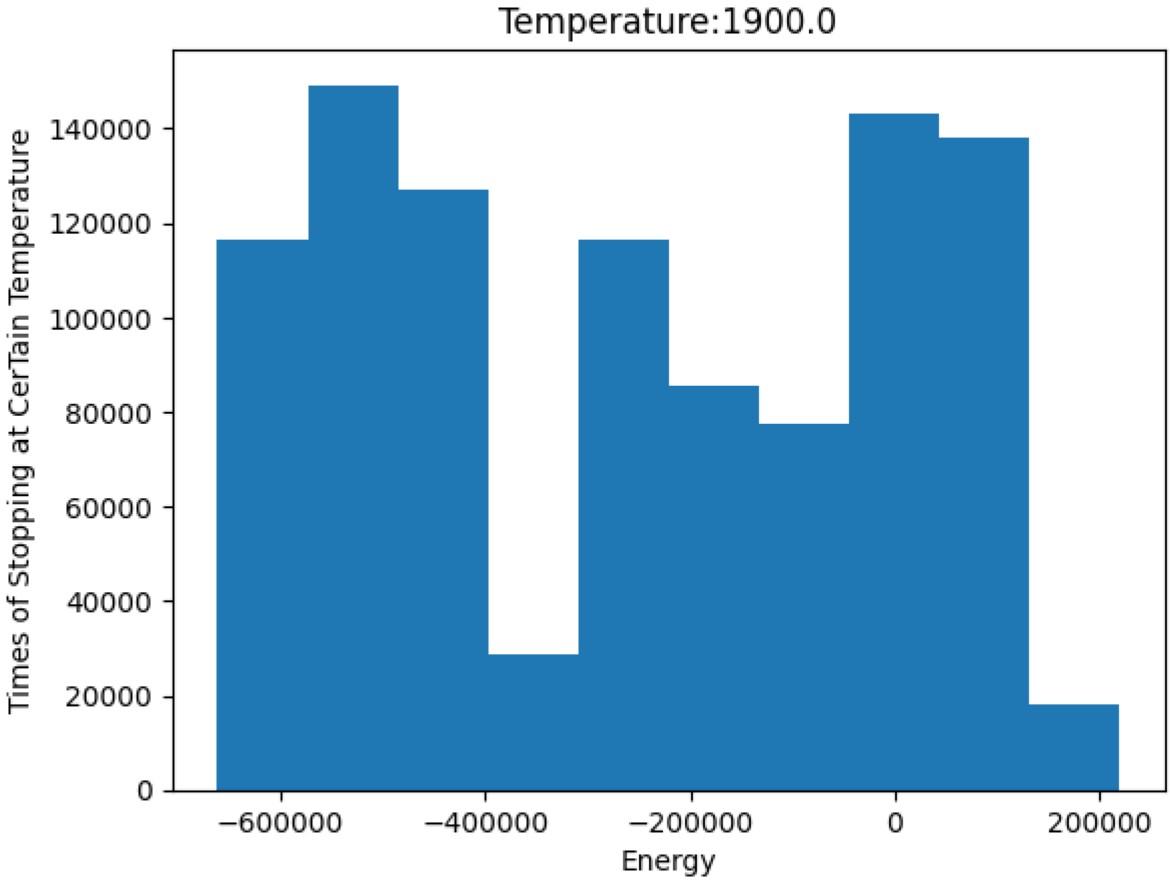
```
Average: -0.7471
```



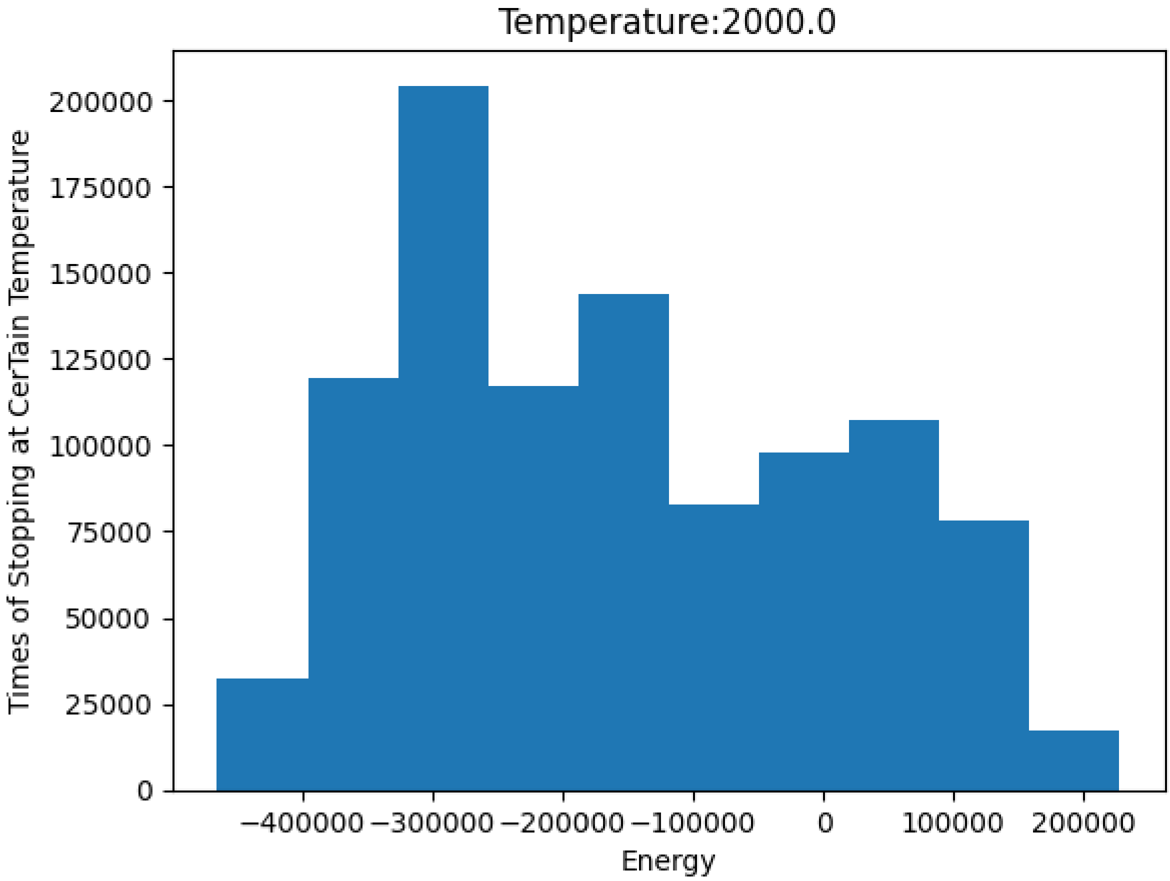
```
Average: -0.988912
```



```
Average: -0.427008
```



```
Average: -0.274004
```



在这里我们可以看到：600单位温度以下都是单峰的情况，600单位温度-1000单位温度是双峰的情况，1000-1200单位温度又变为单峰，1200单位温度左右有个双峰的临界相变点，1600单位温度和1900单位温度也是双峰的临界相变点，另外都是单峰。

In [15]:
```
import matplotlib.pyplot as plt
import numpy as np
def show(s,T):
    x = np.linspace(0,31,32)
    y = np.linspace(0,15,16)

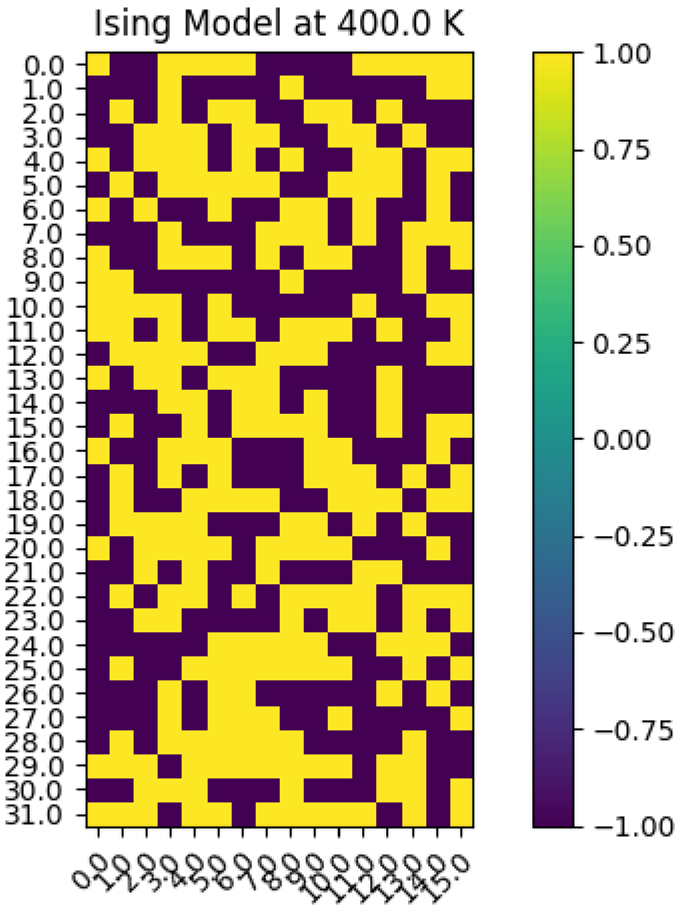


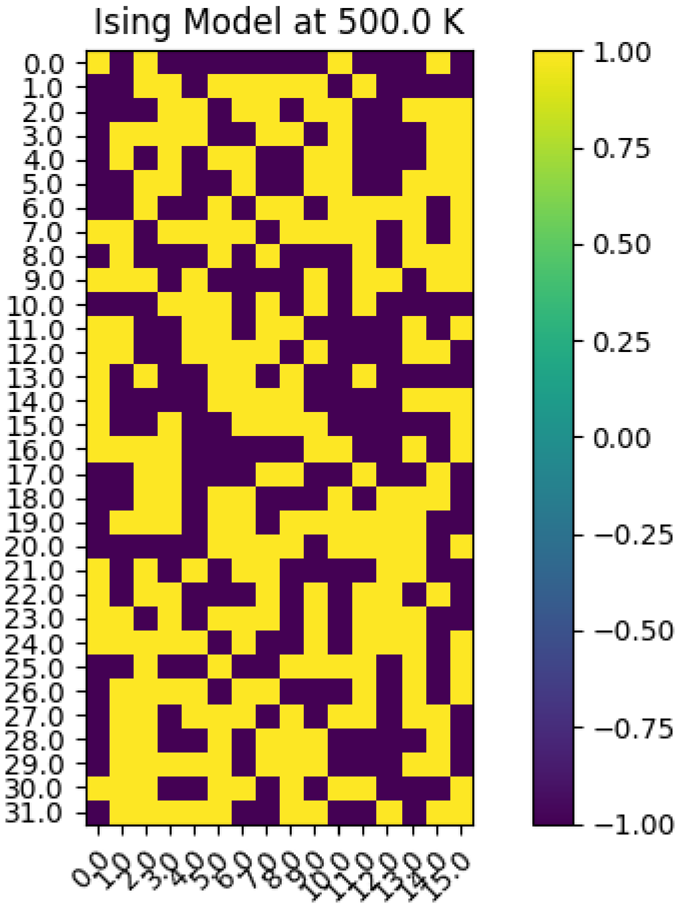
    plt.xticks(y, labels=y,
                    rotation=45, rotation_mode="anchor", ha="right")
    plt.yticks(x, labels=x)
    plt.title("Ising Model at "+str(T)+" K")

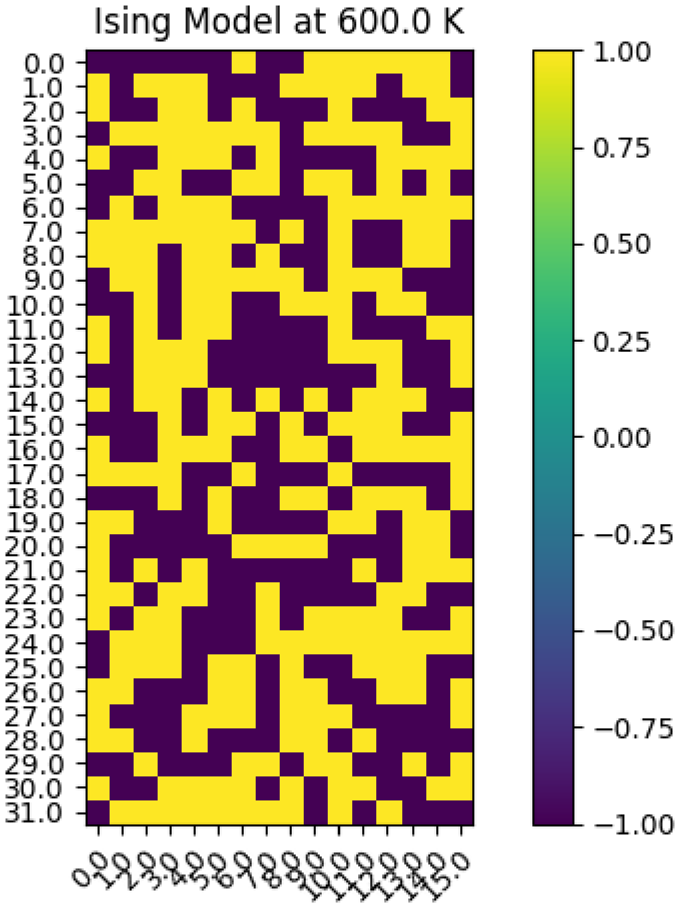

    plt.imshow(s)
    plt.colorbar()
    plt.tight_layout()
    plt.show()

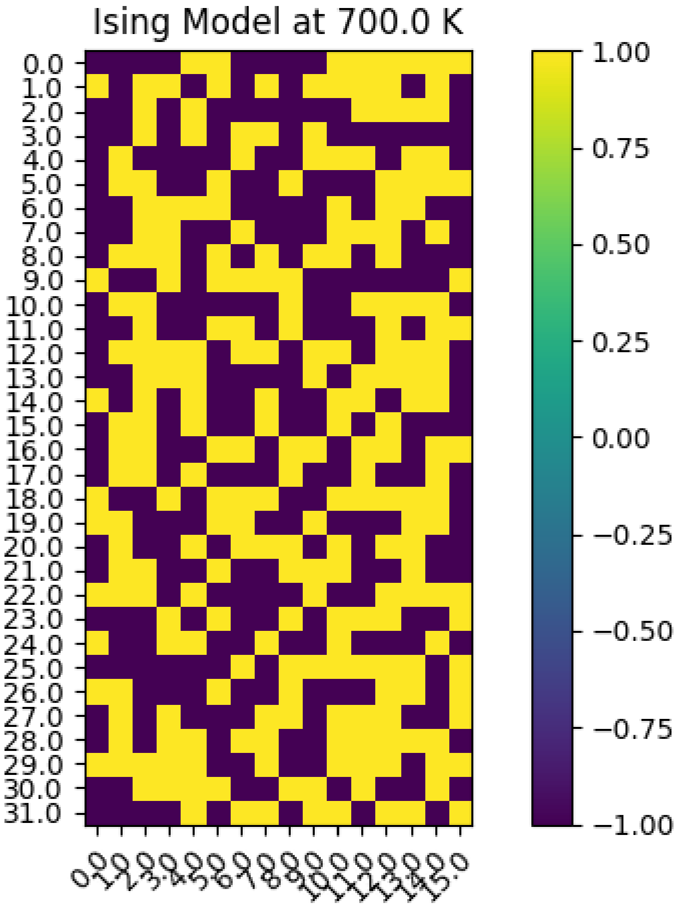

def IsingModel(Length,height,T,Start_Times ,Trial_times):
    beta=1/T
    M=0
    data=[]
    s=2*np.random.randint(0,1,(Length,height))-1
    Es=-np.sum(s[:,0:height-1]*s[:,1:height])-np.sum(s[0:Length-1,:]*s[1:Length,:])
    for t in range(Start_Times+Trial_times):
        location=[random.randint(0,Length-1),random.randint(0,height-1)]
        snew=s
        snew[location[0],location[1]]=-snew[location[0],location[1]]
        Ey=-np.sum(snew[:,0:height-1]*snew[:,1:height])-np.sum(snew[0:Length-1,:]*
        h=min(1,np.exp(-(Ey-Es)*beta))
        u=random.random()
        if u<h:
            s=snew
        if t>=Start_Times:
            M+=np.sum(s)
            data.append(s)
    M/=Trial_times

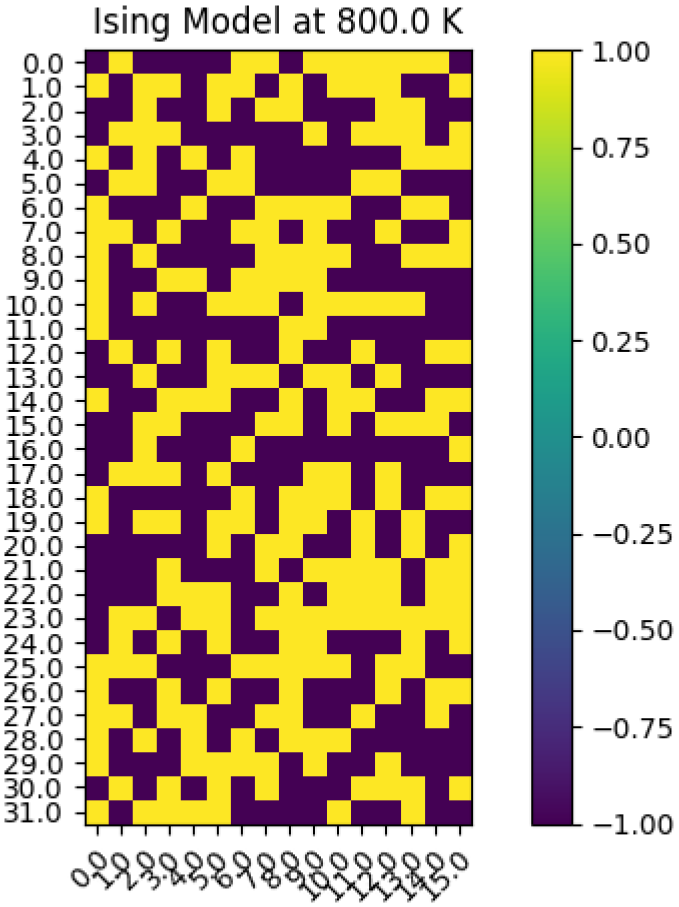
    show(s,T)
    return M
Tlist=np.linspace(400,2000,17).tolist()
for T in Tlist:
    IsingModel(32,16,T,1000000,1000000)
```

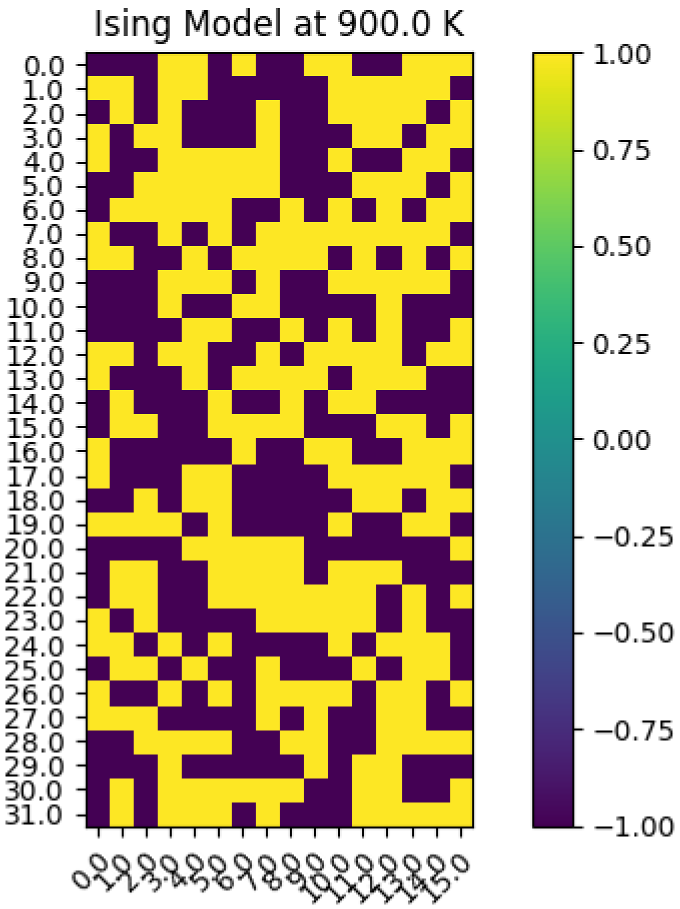


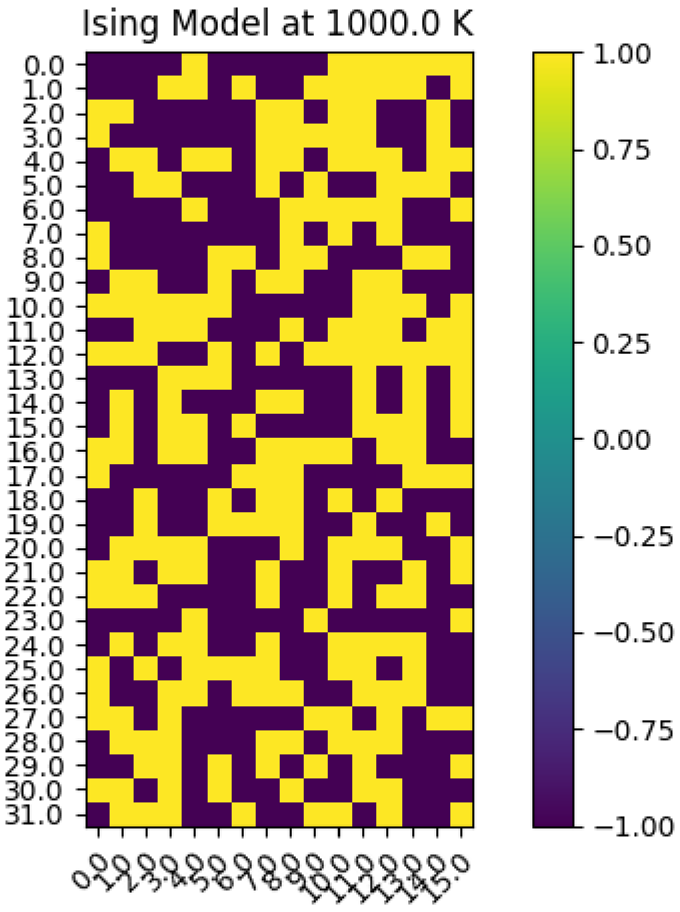

Ising Model at 500.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

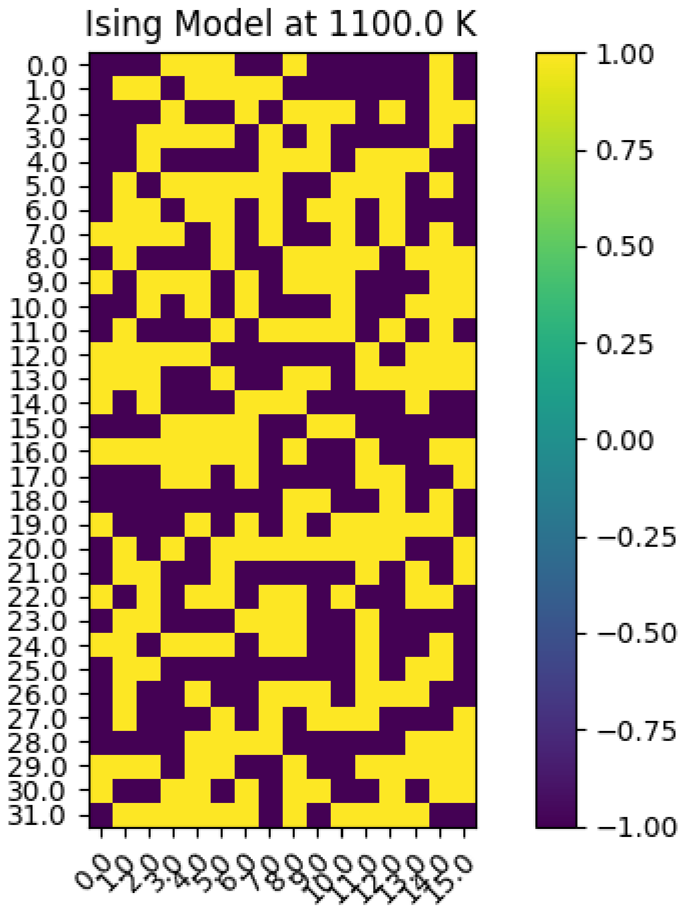

Ising Model at 600.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

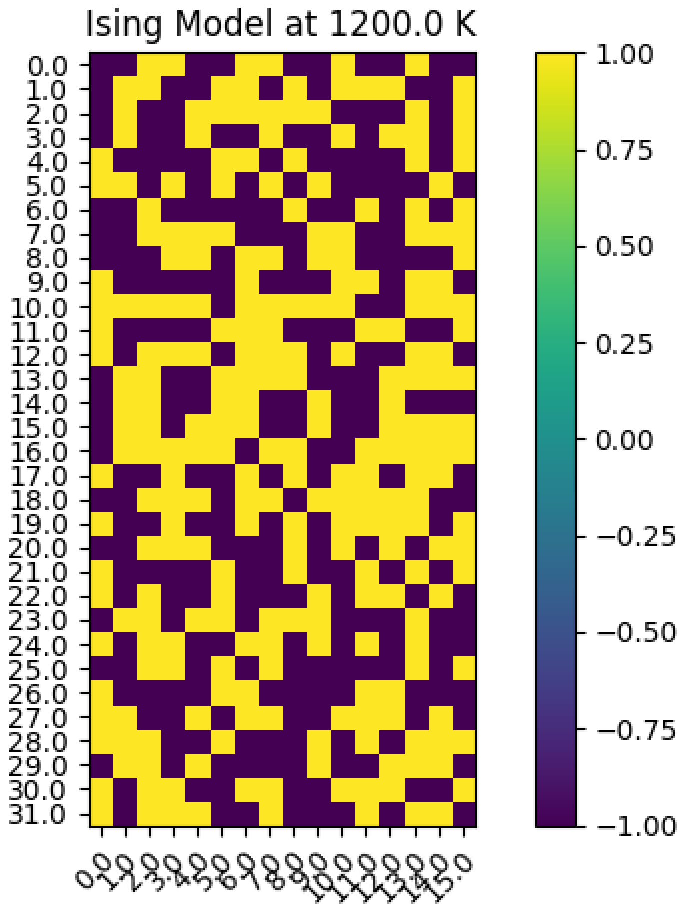

Ising Model at 700.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

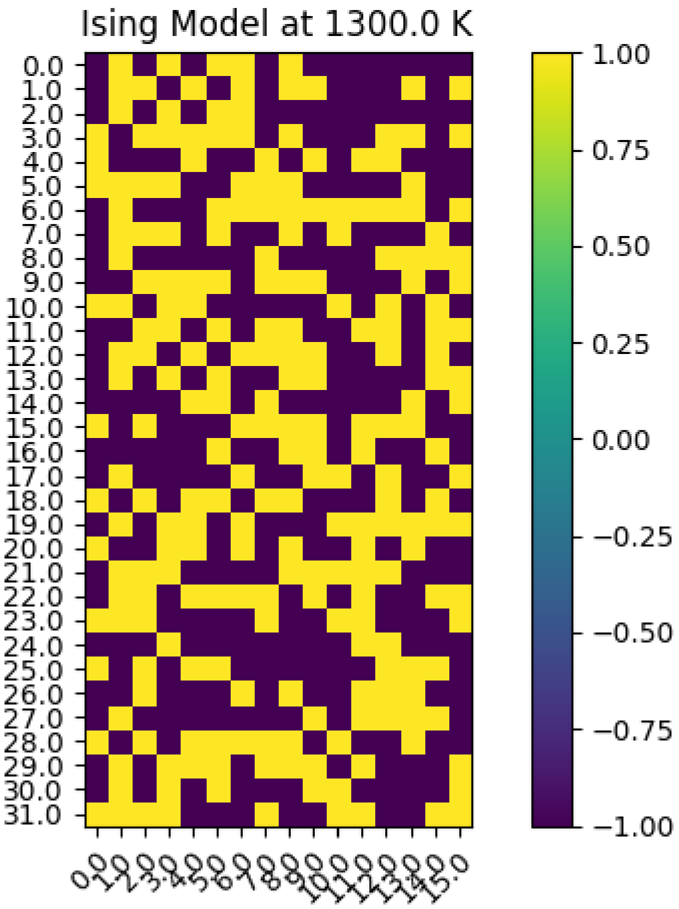

Ising Model at 800.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

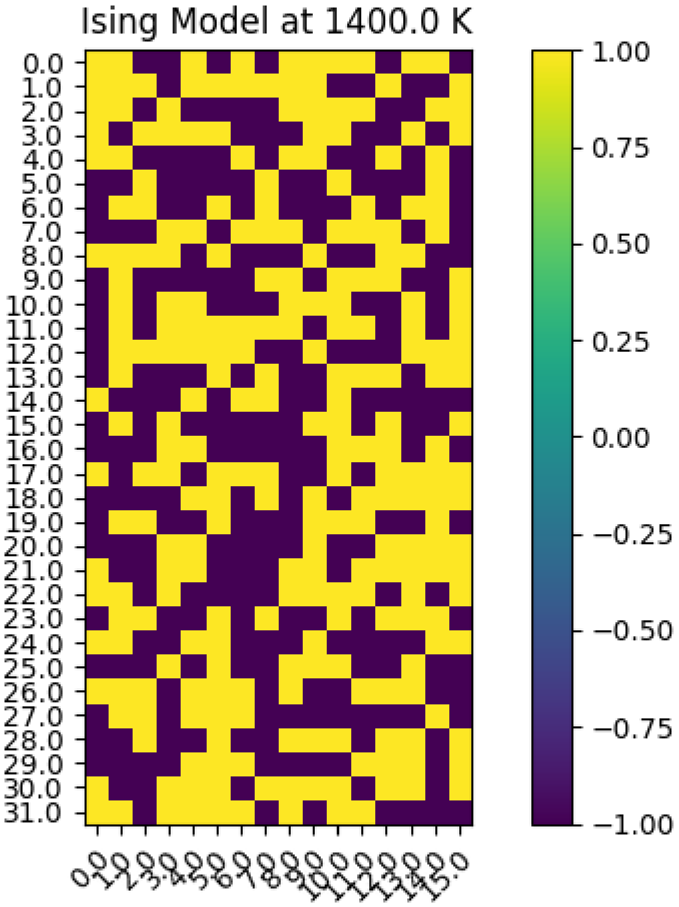

Ising Model at 900.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

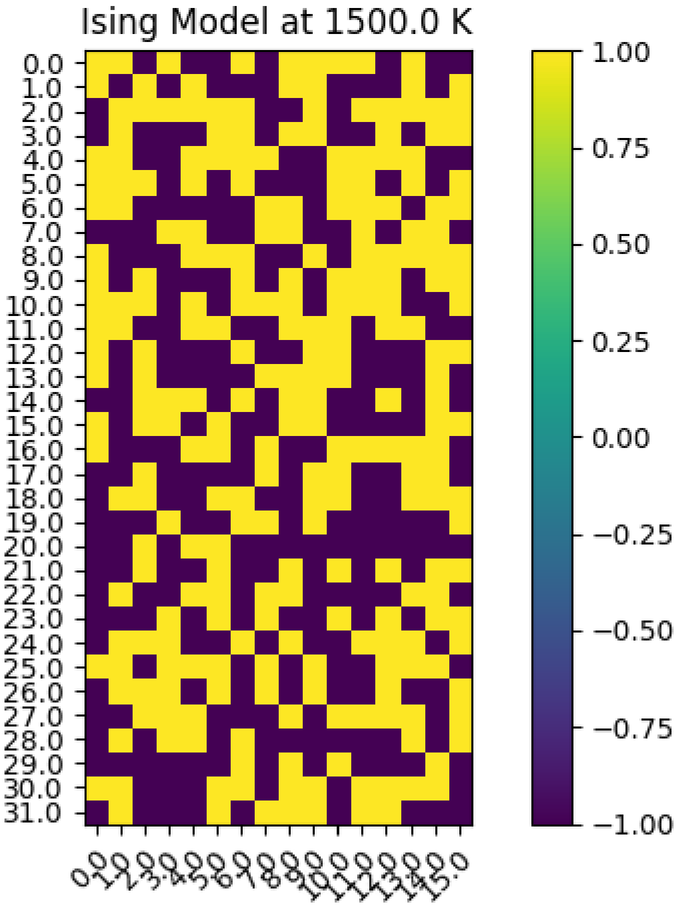

Ising Model at 1000.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

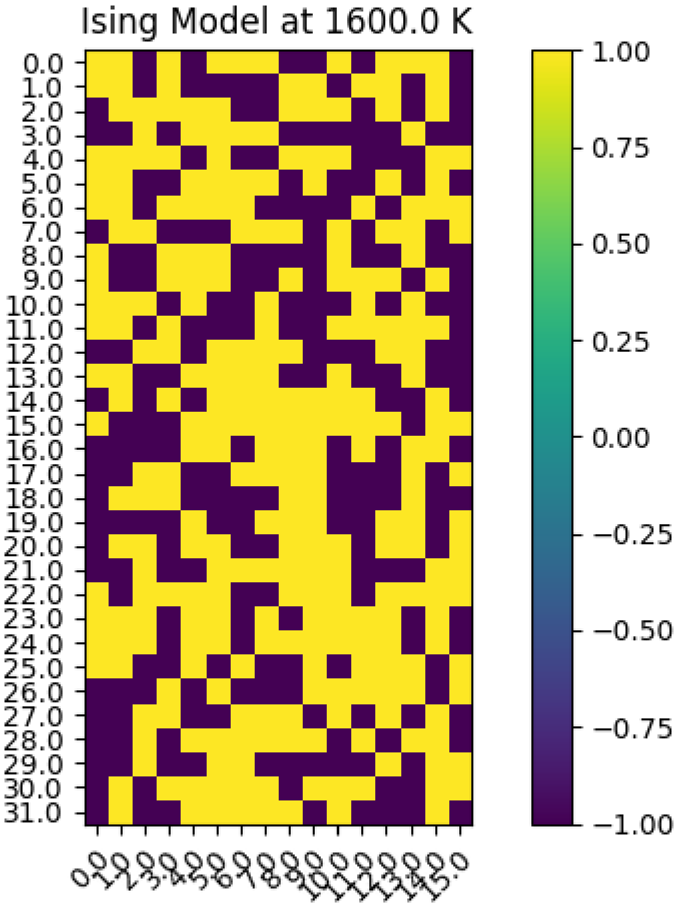

Ising Model at 1100.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

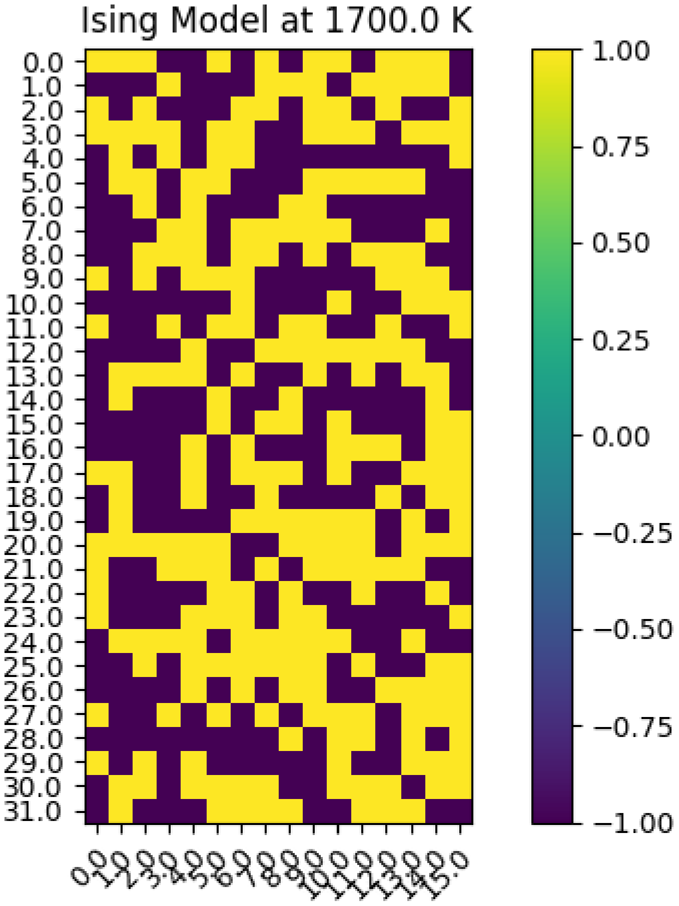

Ising Model at 1200.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00

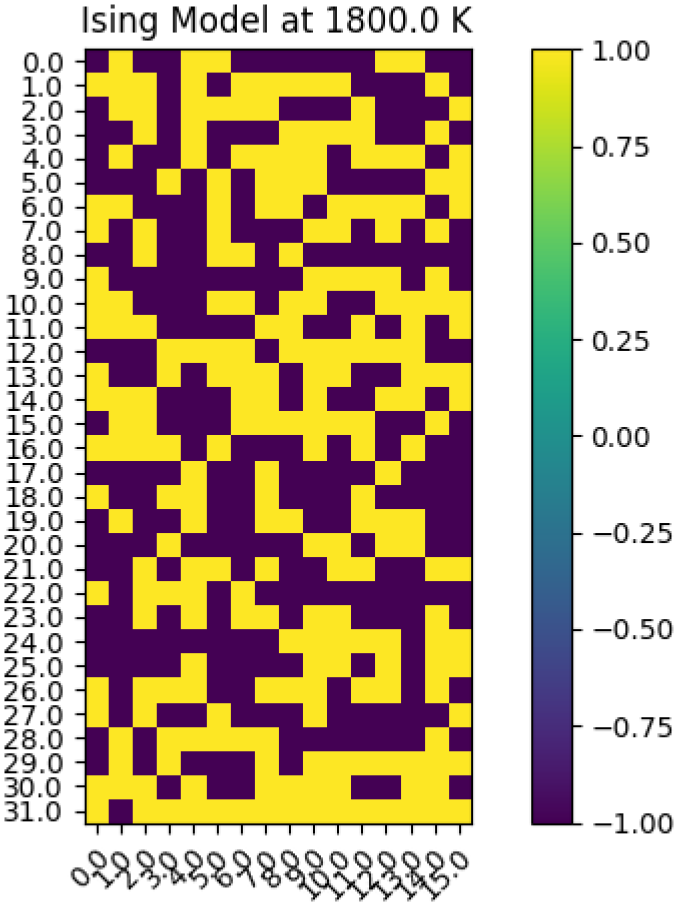

Ising Model at 1300.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00


Ising Model at 1400.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00


Ising Model at 1500.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00


Ising Model at 1600.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00


Ising Model at 1700.0 K
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
31.0
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00


Ising Model at 1800.0 K
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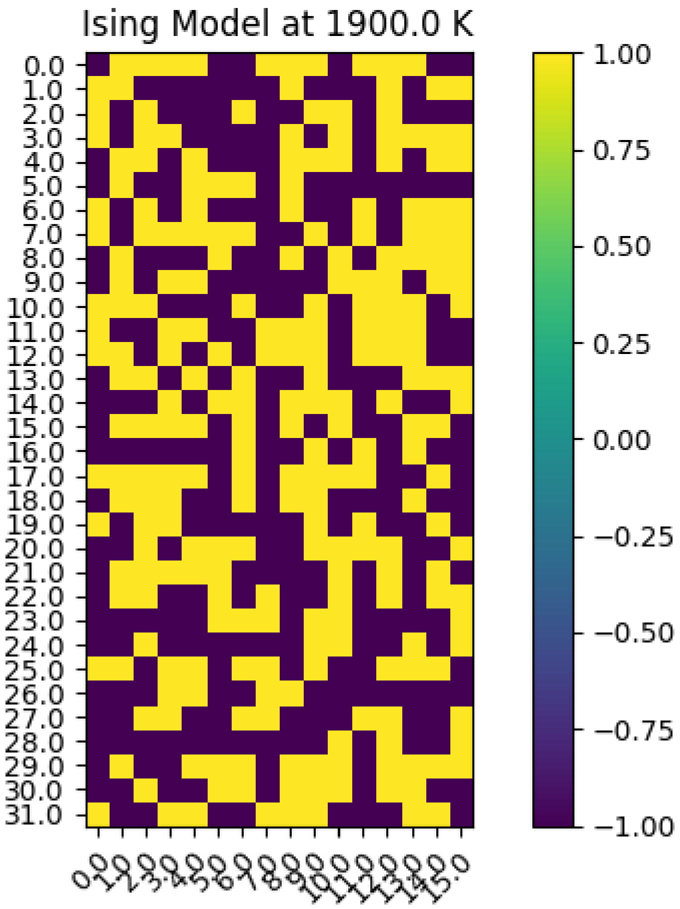
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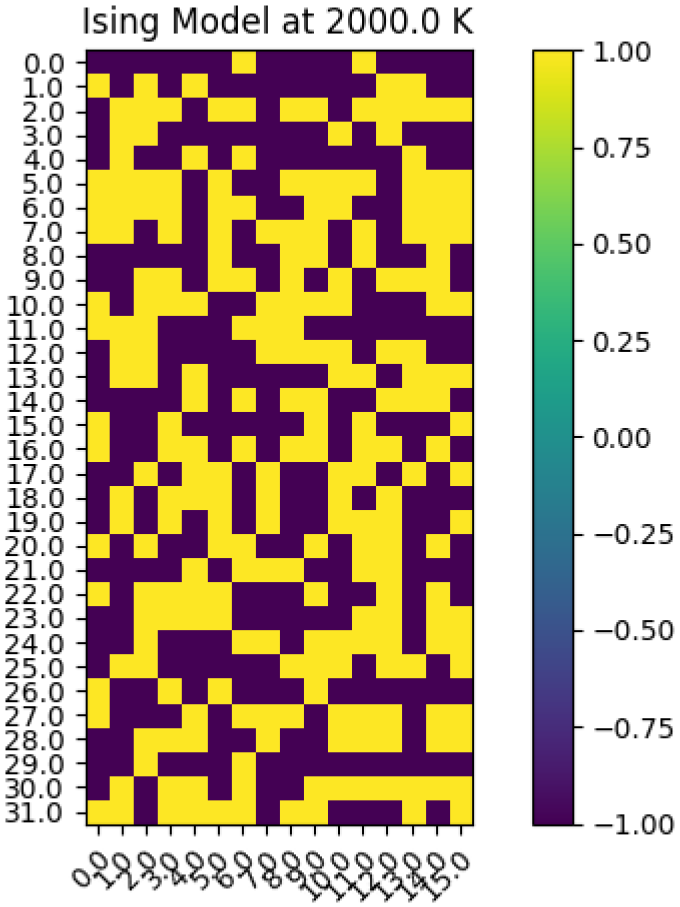
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