PHYS 3142 HW 7

Due date: 11:59 PM 3rd Apr. 2022

- Submit a report that includes your results and your python scripts
- Make sure your code can run
- Write comments in your code
- If you submit the assignment after the deadline or the report is missing, you can only get at most 80% of the full marks.
- If there is any kind of plagiarism, all students involved will get zero marks.

1 Metropolis algorithm for 2D Ising model (100 points)

Use the Metropolis algorithm to simulate the Ising model in a square lattice with 10×10 sites. Use *periodic* boundary conditions. The energy is given by the Hamiltonian which is

$$H = -J \sum_{<i,j>}^{N} S_i S_j \tag{1}$$

where $S_i = \pm 1$ and $< i, j >$ denotes the nearest neighbors.

Use $J = 2$ and $\beta = \frac{1}{k_B} = 1$. Plot the energy $E = \frac{H}{N}$, magnetization M, heat capacity C_v and susceptibility χ with temperature from $T = 1$ to $T = 20$ with $\Delta T = 0.2$.

$$M = \frac{1}{N}\sum_{i}^{N} S_i \tag{2}$$

$$C_v = \frac{\langle E^2 \rangle - \langle E \rangle^2}{k_B T^2} \tag{3}$$

$$\chi = \frac{\langle M^2 \rangle - \langle M \rangle^2}{T} \tag{4}$$

Optional

2 Considering antiferromagnetic interactions(10 points)

Please use the Metropolis algorithm to simulate the Ising model in square lattice with 10*10 sites. The periodic boundary condition is used. The Hamiltonian is:

$$H = -\sum_{<i,j>}^{N} J_{i,j} S_i S_j \tag{5}$$

Now we assume that $J_x = 2$ while $J_y = -1$. (i.e. now the coefficient J is different along x and y direction. The lattice has ferromagnetic interaction along x direction and antiferromagnetic interaction along y direction.) What's the Energy, Magnetization, Heat capacity and Susceptibility of the system then? Please plot the figure of these observables over Temperature from $T = 1$ to $T = 10$ with $\Delta T = 0.2$