Project 2 – Physics 410

October 28, 2016

Monte Carlo Simulation of the 2D Ising model

The project is concerned with simulating the two-dimensional Ising model using the Metropolis-Hastings algorithm. We restrict ourselves to zero magnetic field.

- Generalize the provided code for the one-dimensional Ising model to two dimensions, where the spins are arranged in a square lattice and interact with the nearest neighbours only. Impose periodic boundary conditions in both directions.

- For the coupling $J = 1$ and temperature $T = 3$ plot the total energy of generated configurations as function of time, and determine the approximate time when thermalization occurs. Study this for two lattices with $N \times N$ spins, where $N = 20$ and $N = 40$; how does the thermalization time depend on the lattice size?

- For each one of the following quantities, determine and plot their dependence on temperature (for T between 2 and 2.6, in steps of 0.02). Use an $N \times N$ lattice (for N=10,20,50) and calculate the average using $5 \times 10^4 N^2$ thermalized configurations.

  The quantities to determine are: energy, magnetization, heat capacity, magnetic susceptibility.

- Identify the approximate location of the phase transition, the Curie temperature, for the two-dimensional Ising model. Note that for temperatures near the critical point, thermalization takes longer (this is know as critical slow down), so you might want to re-examine the thermalization time and adjust parameters accordingly. Which observable gives the clearest signature of the transition?