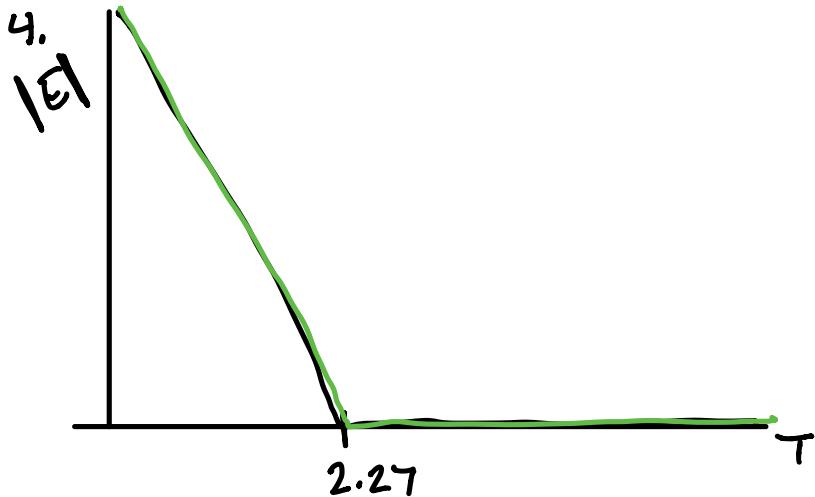


## Activity 13

### Simulation of 2D Ising

1. ✓
2. There seems to be an equal number of the two alignments. But, many of the neighboring pairs seem to be opposite spin. This means that @  $T=10$  the energy of the system is higher, and constant.
3. Mine did always end up in a uniform ferromagnetic state at low  $T$ , but not @ high  $T$ .  
for low  $T$  we had  $E = +N$  or  $-N$   
for high  $T$  we had  $E \approx 0$



5. smaller sizes are more likely to be ferromag, even around the critical point of 2.27.

## Monte Carlo Sampling

1. • The code starts with  $J=1$ , which is ferromagnetic, and  $J=-1$ , which is antiferromagnetic. The lowest  $E$  has spins aligned with the field.

- add  $-\sum H S_i$  to the "calculate-energy" portion of the code.

- microstates = 2<sup>20</sup>

there are  $2^{20}$  configurations

$$\text{time} = \frac{2^{40}}{2^{20}} \quad 2^{20} \times \text{longer?}$$

- Max  $E = +20$       min  $E = -20$

or 0 when all unaligned.

I am going to guess all values between -20 and +20 are possible, so 41 Energies.

- Boundary conditions

- we have a continuous band where site 20 wraps around to meet w/ site 1.

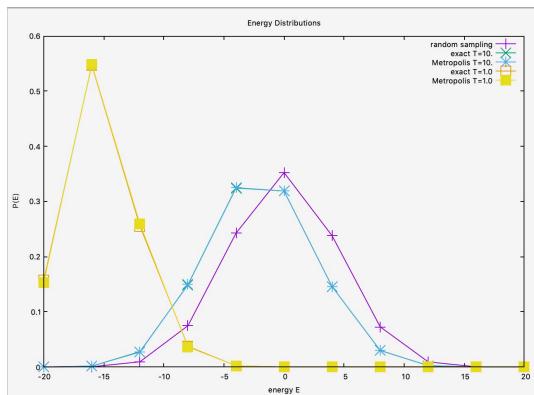
the other option would be to have site 1 and site 20 be disconnected, this way the endpoints only have 1 neighbor.

- $Z_{\text{exact}} = \sum (\text{E count}(i)) \cdot e^{-E_i/kT}$

and later it adds the # of states w/ Energy

2. No, I definitely overcounted by not considering degenerate states.

3.



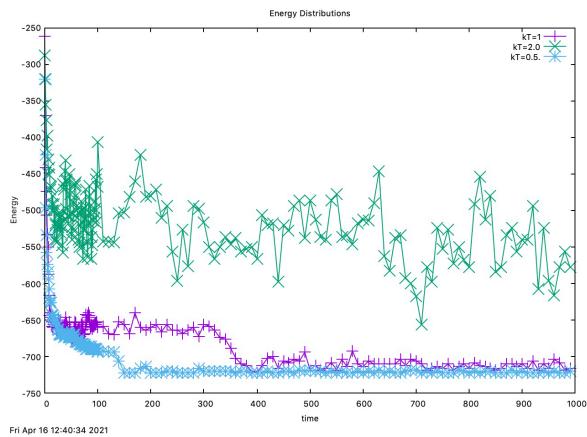
- Ordinary random sampling is entirely random. All 3D states have equal probability, the average  $\langle E \rangle$  should be around 0 in this case. I'd guess  $T$  is infinitely high or where  $kT = \infty = 0$   
 $\hookrightarrow T$  is infinitely high
- random sampling is done @ too high a  $T$ . It's not going to give physical results. Yes, metropolis lines up pretty close w/ the "exact" results.
- line 17a looks like 2.1.3a.b.  
- and I switched it to a ✓ to check

5 Change PE to  $KE = \text{total } E - PE$

## The Two-D Ising Model

1. 1D Ising models take into account only the two neighbors on either side. The 2D models require the 4 neighbors, two on either side, and the ones above and below.

2.

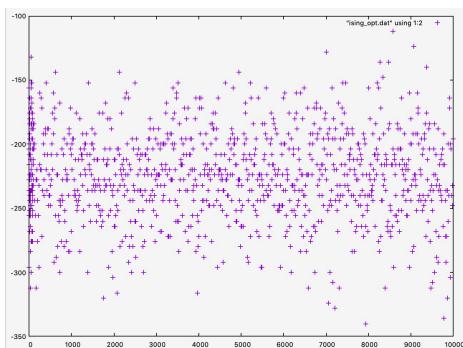


- I kept getting the final E to be around -710.
- High KT never really reached equilibrium, KT=0.5 reached equilibrium @ 150
- KT = 1.0 would reach equilibrium at various times.

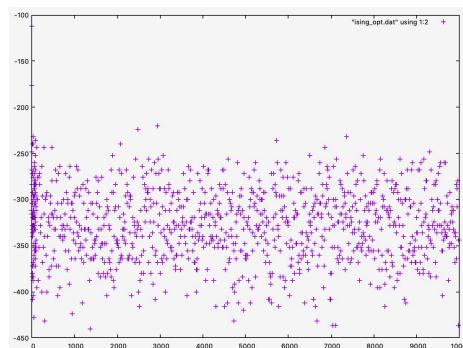
3. Change J\_ising from +1 to -1

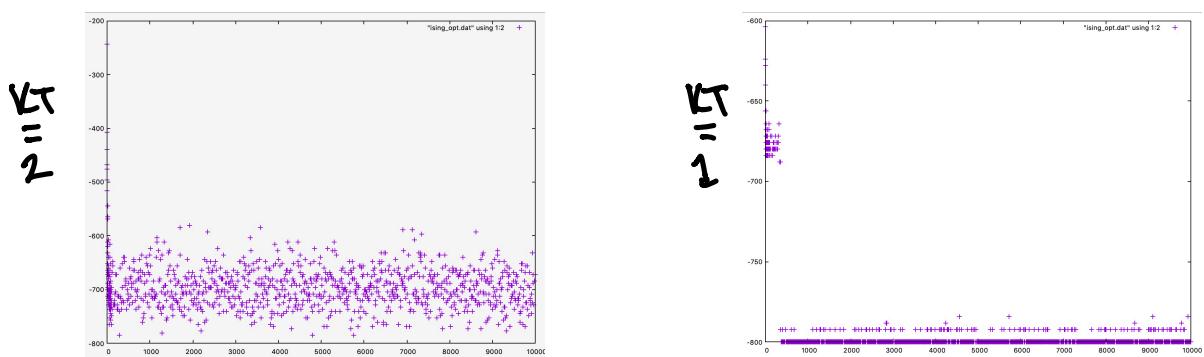
4. I do not have a clue how to implement this...  
(plus I am too late for office hours)

6.  
KT = 4



KT = 3





It seems to become magnetized

- use the absolute value because spin can be up or down.
- The larger the  $L$ , the larger the system and a better likelihood of reaching equilibrium