Ising Model - Parting Shots

- We discussed continuous phase transitions in this specific context, but the lessons are much broader
- There is an important notion of *universality*:
  - the critical properties (exponents etc.) of continuous transitions depend on very few things - symmetry, dimensionality being the main ones
  - otherwise, transitions involving the same symmetries, even in completely different physical systems, show the same critical behavior - examples??

Universality

- One explanation: Landau theory
  - Near criticality, the order parameter is small, and one can Taylor expand the free energy in it. This gives a form which depends only on symmetries
- Renormalization group provides a more refined explanation

Antiferromagnets

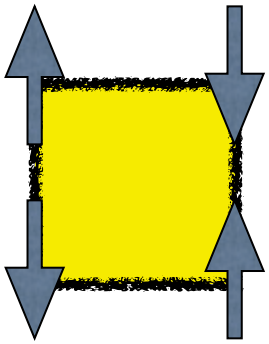
- So far, we have talked about the Ising ferromagnet, which is about the simplest model of statistical mechanics
- Often much complex interactions and/or more complex ordering arises and the statistical mechanics becomes much more involved - and more interesting!
- In the case of magnetic systems, *antiferromagnets* show this kind of richness

Antiferromagnets

- Antiferromagnet: 2 definitions
  - A magnet which orders but has no net magnetization
  - A material with exchange interactions which prefer anti-aligned spins
- Could be both, either, or neither, but both is common

Bipartite AFs

- A lattice is bipartite if it can be divided into two sets of sites, A and B, with A sites neighboring B sites *only*, and vice-versa
- Then AF exchange is easily satisfied with A and B spins antiparallel

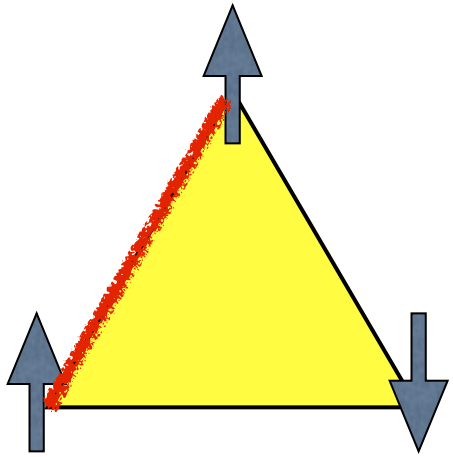


In this case, classical problem can be mapped back to the FM one by $S_B \rightarrow -S_B$

Frustration

- Competing interactions generate degenerate ground states

Ising spins



"geometric frustration"