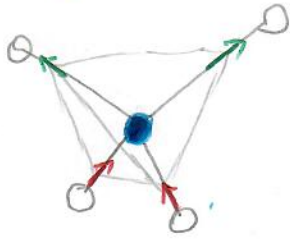


Spin ice, frustrated pyrochlores

Def. Magnetic substance with more than one minimal energy state.



Tetrahedron
far Hydrogen
close Hydrogen

6 different ways

Follows ice rules \rightarrow residual entropy (measure by integrating heat capacity)

Use entropy at $T \rightarrow \infty$ energy $S = Nk_B \log 2$

Difference to ferro is that spin ice is macroscopically degenerate, can change some directions without changing system.

○ Ferromagnetic coupling

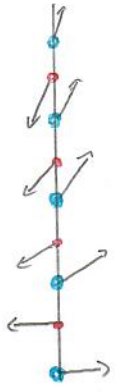
Quantum spin chains and Haldane Gap

Failure of classical spin wave theory in 1D.



Néel state unstable in 1-D spin chains (Heisenberg Model) due to HMMW.

Multiferroics



breaks symmetry inversion
 \Rightarrow DM possible
 \Rightarrow electrical polarization

Frustration induced
helimagnet
DM interaction forbidden

Def. more than one of the
primary ferroic properties
in the same phase:

- ferromagnetism
- ferroelectricity
- ferroelasticity

Type I: at different temperature and different mechanism

Type II: T_c identical, coupled mechanism