Macroscopic magnetization jumps due to independent magnons on frustrated quantum spin lattices

Jürgen Schnack, Heinz-Jürgen Schmidt
Universität Osnabrück, D-49069 Osnabrück

Jörg Schulenburg, Johannes Richter
Universität Magdeburg, P.O. Box 4120, D-39016 Magdeburg

Andreas Honecker
TU Braunschweig, Mendelssohnstr. 3, D-38106 Braunschweig

http://obelix.physik.uni-osnabrueck.de/~schnack/
Kagomé Lattice
Giant Magnetisation Jump

Heisenberg model: antiferromagnetic nearest neighbour interaction

Icosidodecahedron with $s = 1/2$

Heisenberg model: antiferromagnetic nearest neighbour interaction

Localized Magnon – Example

- \( |\text{localized magnon}\rangle = \frac{1}{2} (|1\rangle - |2\rangle + |3\rangle - |4\rangle) \)
- \( |u\rangle = s^{-1}(u) |\Omega\rangle; \ |\Omega\rangle \) magnon vacuum; \( u = 1, 2, 3, 4 \)
- \( H |1\rangle = J\{|1\rangle + 1/2(|2\rangle + |4\rangle + |5\rangle + |8\rangle)\} \)
- \( H |\text{localized magnon}\rangle \propto |\text{localized magnon}\rangle \)
- triangles trap the localized magnon, amplitudes cancel at outer vertices;
- proven for \( s = 1/2 \), one exchange constant \( J \), and same number of interactions for each site;
- result also holds for \( s > 1/2 \) and XXZ model \( (\Delta \geq 0) \), so far numerical evidence, proof in preparation.
Kagomé Lattice – Independent Magnons

- localized one-magnon state indicated by bold lines;
- independent (non-interacting) one-magnon states can be placed on the grid (circles);
- due to the absence of attractive interaction, each state of $n$ independent magnons is the ground state in the Hilbert subspace with $M = Ns - n$;
- $\Rightarrow$ linear dependence of $E_{\text{min}}$ on $M$;
- $\Rightarrow$ magnetisation jump;
- maximal number of independent magnons: $N/9$;
- magnetisation jump is a macroscopic quantum effect!
Structures with Magnetisation Jump

a) \(-\sqrt{2(1+\Delta)}\)

b) 

c)