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

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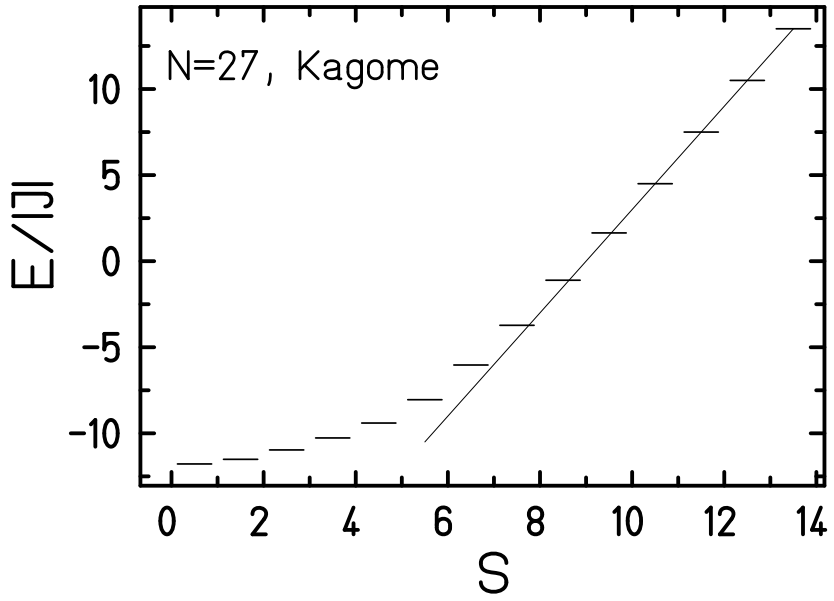
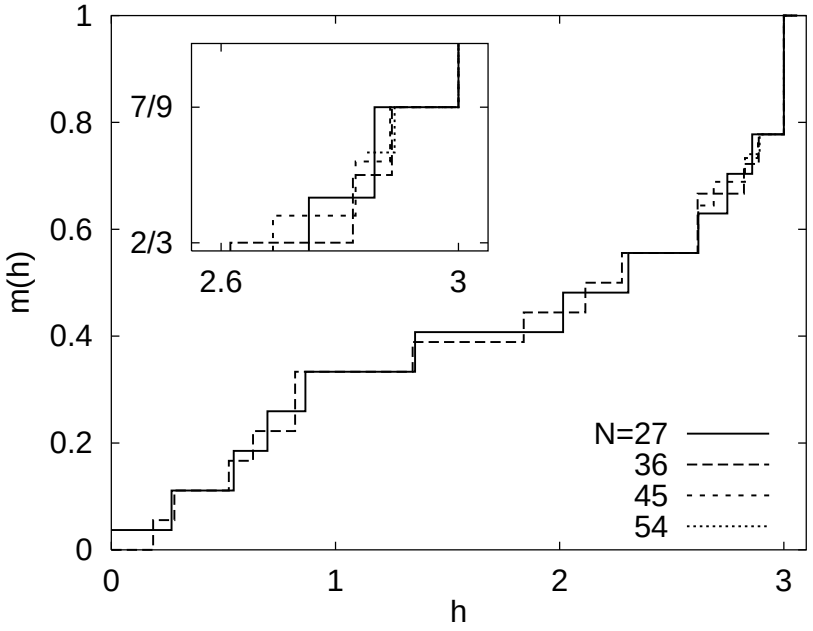
Kagomé Lattice
Giant Magnetisation Jump

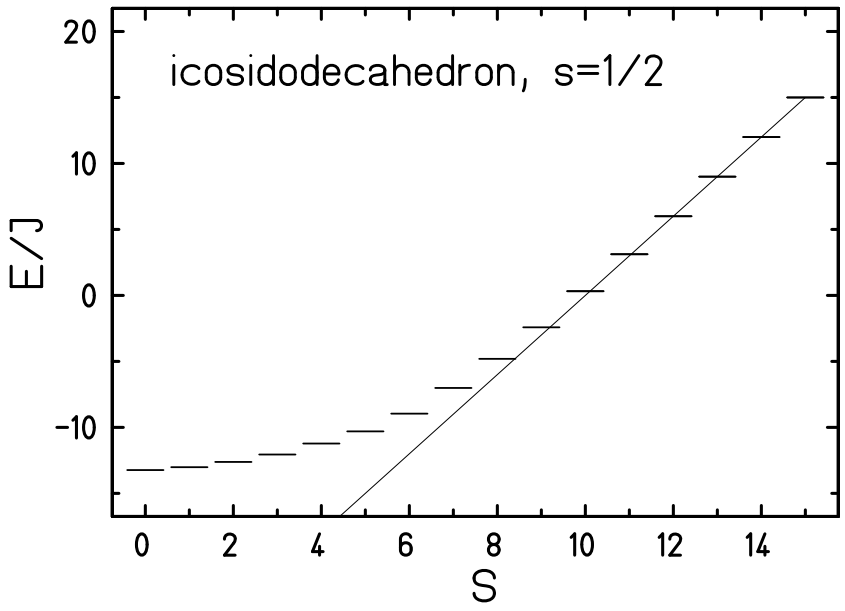


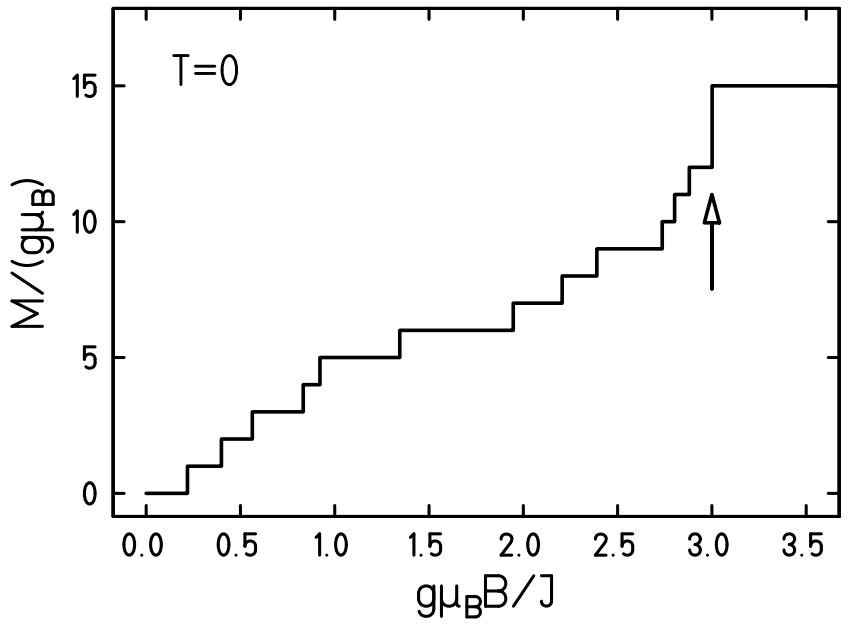


Heisenberg model: antiferromagnetic nearest neighbour interaction

J. Schulenburg, A. Honecker, J. Schnack, J. Richter, H.-J. Schmidt, *Macroscopic magnetization jumps due to independent magnons in frustrated quantum spin lattices*, Phys. Rev. Lett. (2002) accepted; cond-mat/0108498

Icosidodecahedron with $s = 1/2$

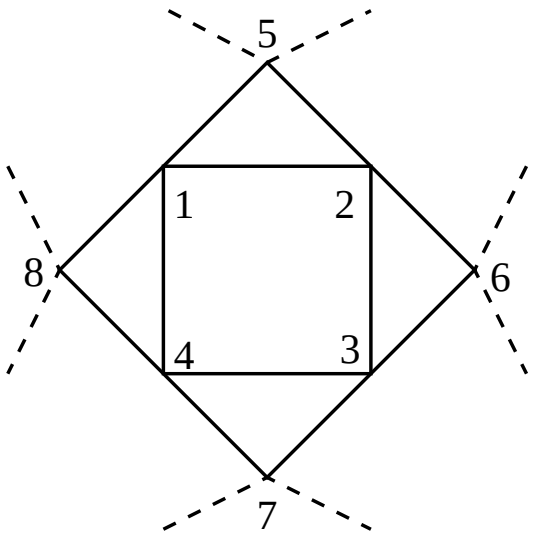




Heisenberg model: antiferromagnetic nearest neighbour interaction

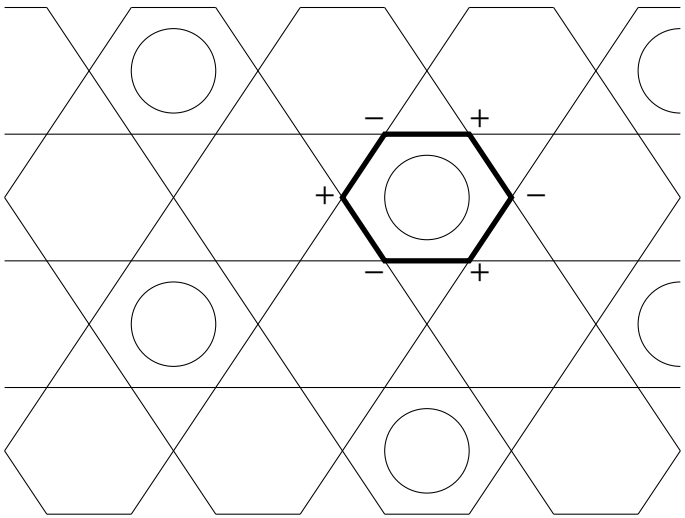
J. Schnack, H.-J. Schmidt, J. Richter, J. Schulenburg, *Independent magnon states on magnetic polytopes*, Eur. Phys. J. B **24** (2001) 475

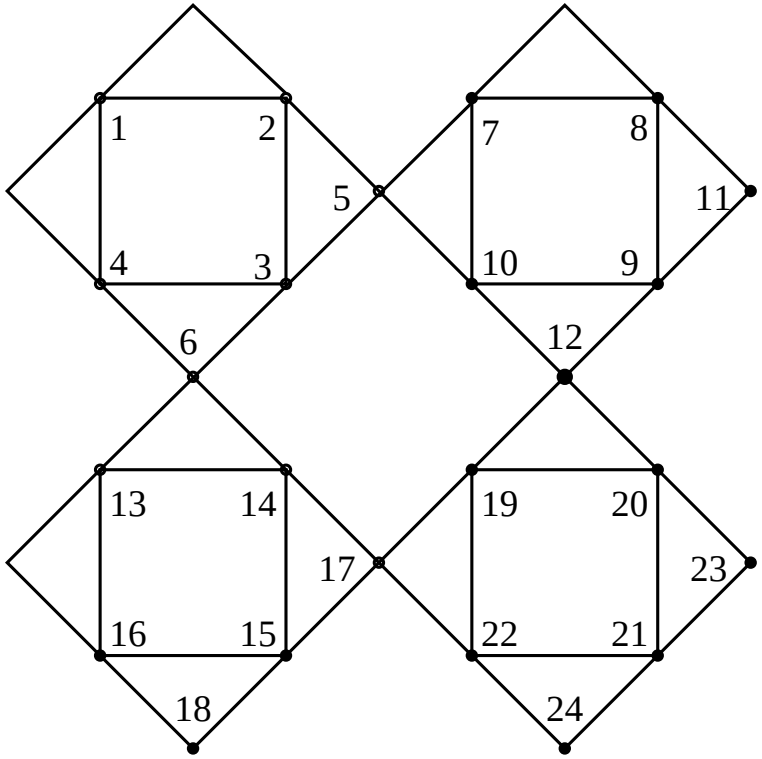
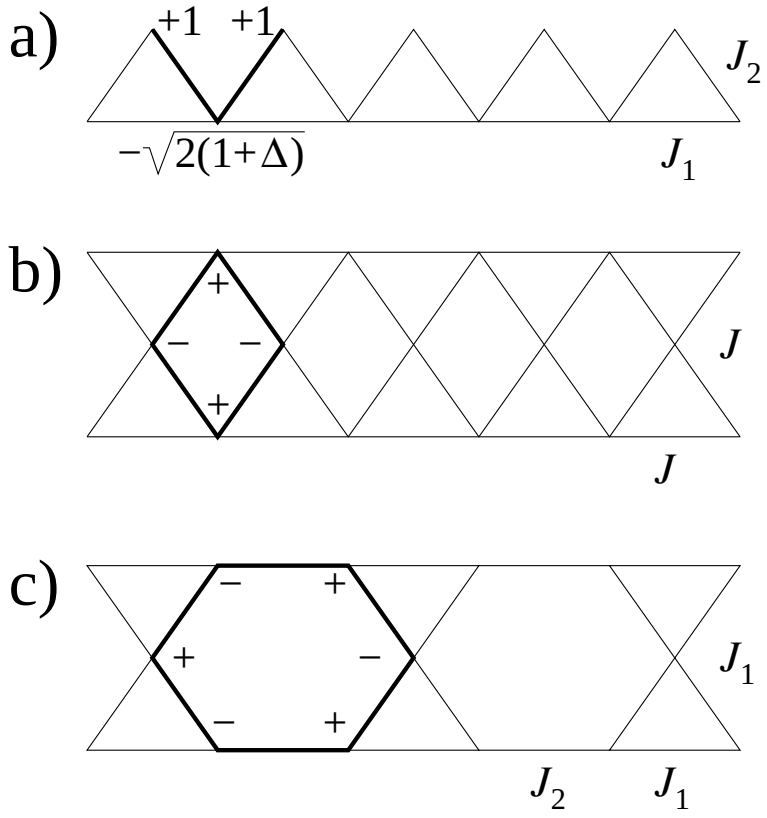
Localized Magnon – Example



- $|\,\text{localized magnon}\,\rangle = \frac{1}{2}\,(\,|\,1\,\rangle - |\,2\,\rangle + |\,3\,\rangle - |\,4\,\rangle)$
- $|\,u\,\rangle = \underset{\sim}{s}^{-}(u)\,|\,\Omega\,\rangle$; $|\,\Omega\,\rangle$ – magnon vacuum; $u = 1, 2, 3, 4$
- $\underset{\sim}{H}\,|\,1\,\rangle = J\{\,|\,1\,\rangle + 1/2(\,|\,2\,\rangle + |\,4\,\rangle + |\,5\,\rangle + |\,8\,\rangle)\}$
- $\underset{\sim}{H}\,|\,\text{localized magnon}\,\rangle \propto |\,\text{localized magnon}\,\rangle$
- 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 $E_{\min}$ on M;
- $\Rightarrow$ magnetisation jump;
- maximal number of independent magnons: N/9;
- magnetisation jump is a macroscopic quantum effect!

Structures with Magnetisation Jump