Thermodynamics of the N=42 kagome lattice antiferromagnet and magnon crystallization in the kagome lattice antiferromagnet

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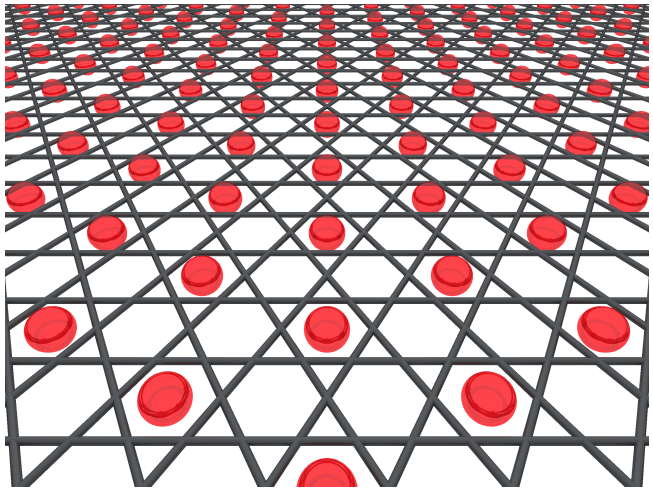
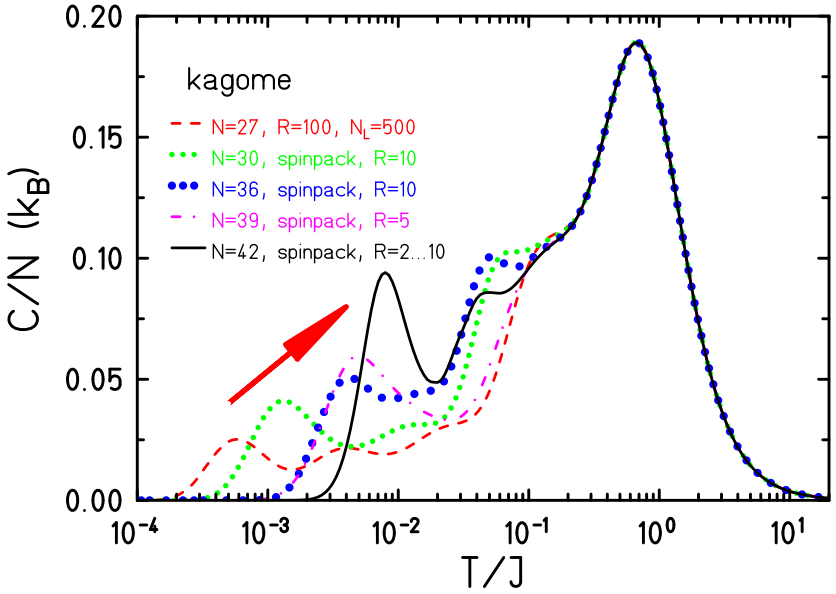
Kagome lattice antiferromagnet – scientific problems

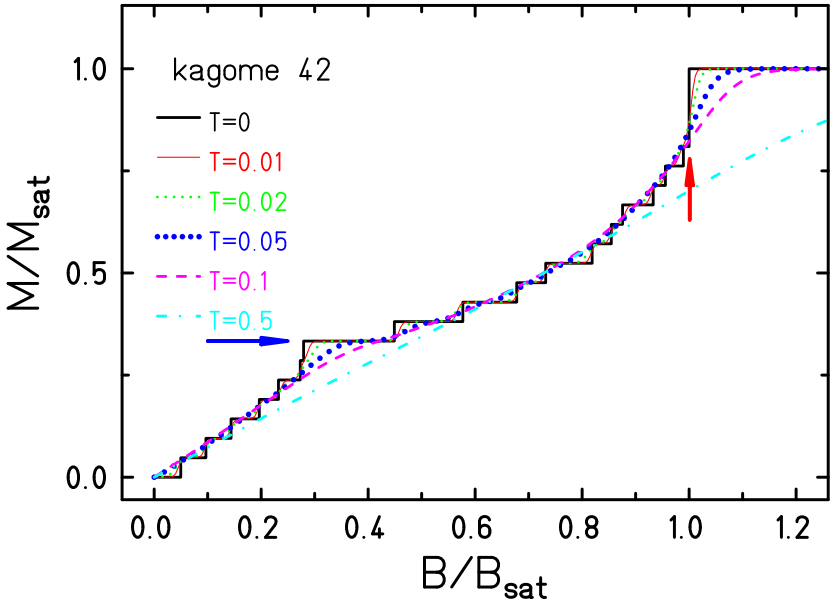


- Thermodynamic functions (1)
- “Condensation” of low-lying singlets below the first triplet?
- Magnetization jump to saturation
- Thermal stability of magnetization plateaus
- Crystallization of localized magnons?
- Notoriously enigmatic (2)!

(1) J. Schnack, J. Schulenburg, J. Richter, Phys. Rev. B **98**, 094423 (2018)
(2) A.M. Läuchli, J. Sudan, R. Moessner, Phys. Rev. B **100**, 155142 (2019)

Reminder: Kagome 42 – magnetic properties

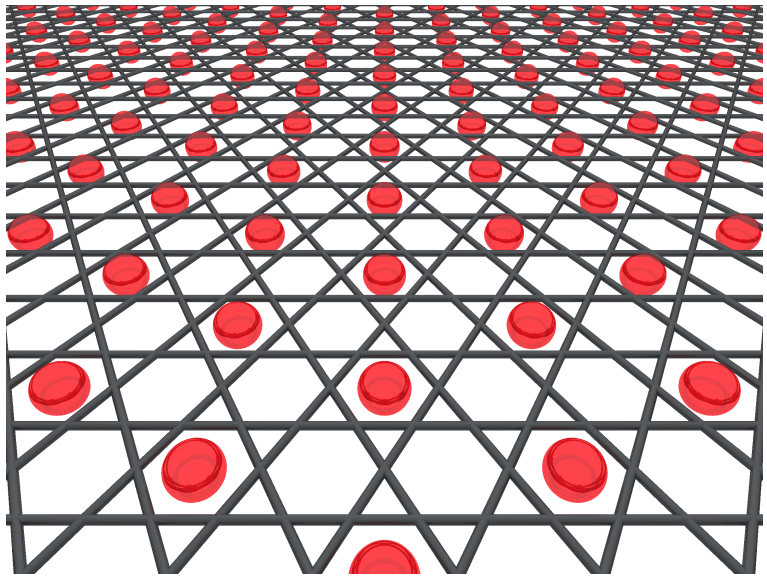


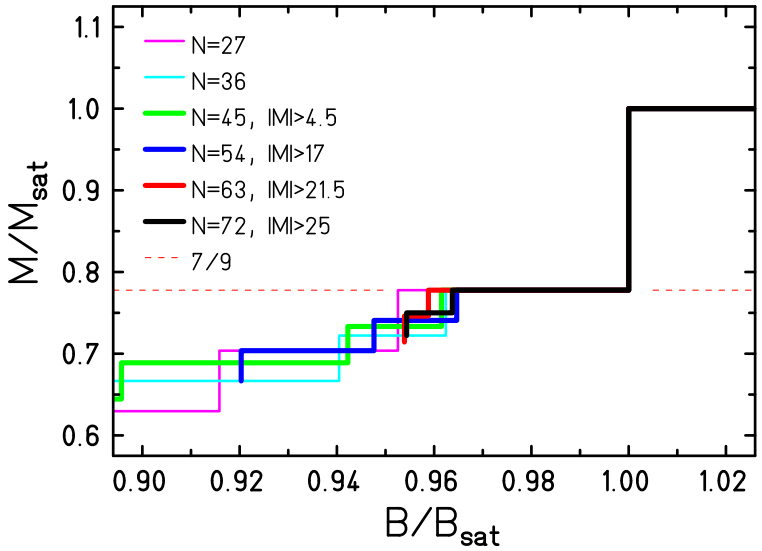


- Low-T peak moves to higher T with increasing N, maybe to form shoulder (2).
- Density of low-lying singlets seems to move to higher excitation energies!
- Magnetization exhibits plateaus and giant jump to saturation.

(1) J. Schnack, J. Schulenburg, J. Richter, Phys. Rev. B **98**, 094423 (2018)
(2) Xi Chen, Shi-Ju Ran, Tao Liu, Cheng Peng, Yi-Zhen Huang, Gang Su, Science Bulletin **63**, 1545 (2018).

Kagome – magnetization jump due to independent magnons



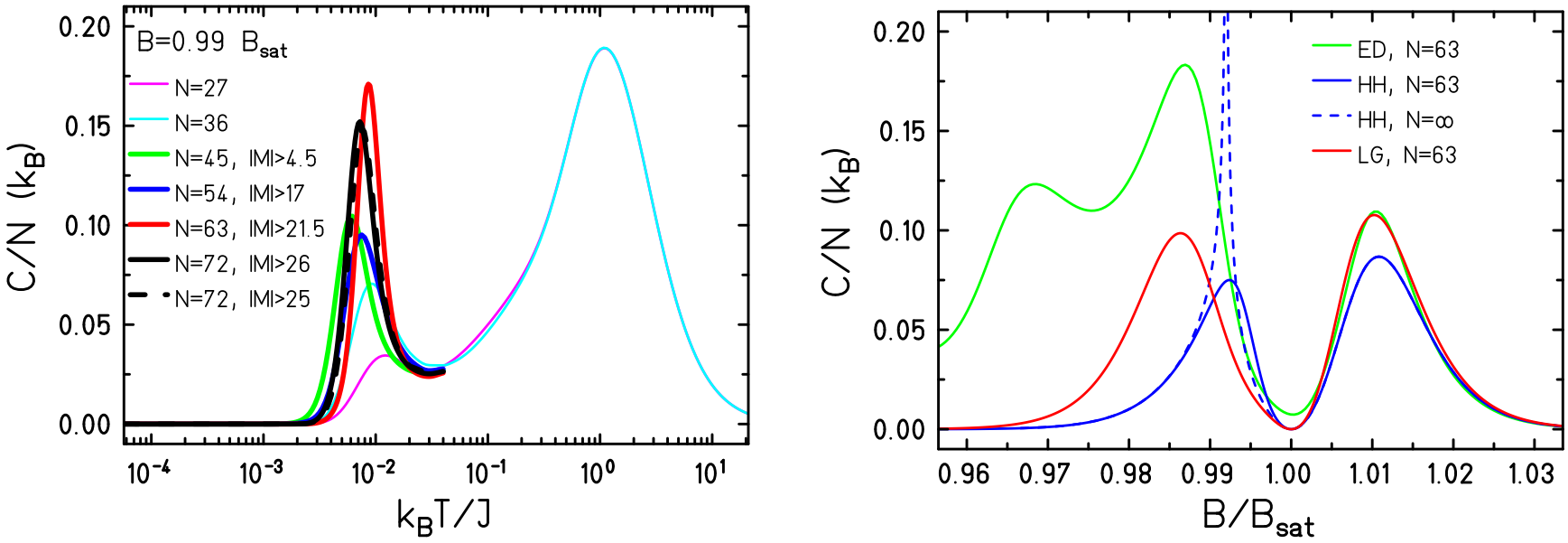


- Nearest-neighbor Heisenberg model: independent one-magnon states are eigenstates and ground states below the saturation field.

- They lead to flat bands and can be localized as well.

J. Schnack, H.-J. Schmidt, J. Richter, J. Schulenburg, Eur. Phys. J. B **24**, 475 (2001)
J. Schulenburg, A. Honecker, J. Schnack, J. Richter, H.-J. Schmidt, Phys. Rev. Lett. **88**, 167207 (2002)

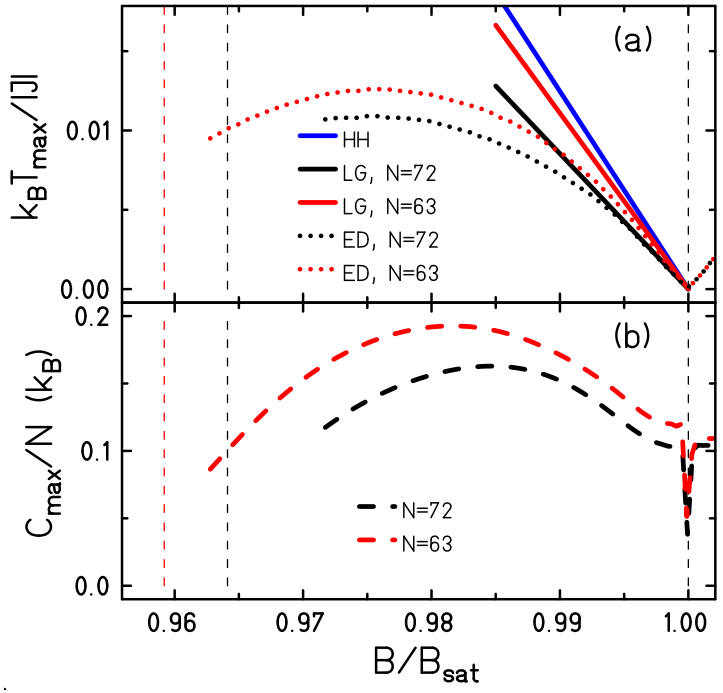
Kagome – crystallization of magnons



- Finite-temperature continuous transition to a magnon crystal (universality class of the two-dimensional three-state Potts model).
- Numerical investigation with FTLM up to $N = 72$: rounded peaks in C vs T (1).
- Qualitative agreement with loop gas model as well as hard hexagon model (2).

(1) J. Schnack, J. Schulenburg, A. Honecker, J. Richter, Phys. Rev. Lett. **125**, 117207 (2020)
(2) M. E. Zhitomirsky and Hirokazu Tsunetsugu, Phys. Rev. B **70**, 100403(R) (2004)

Kagome – crystallization of magnons



- Crystallization of localized magnons (1).
- T-B phase diagram for finite lattices.
- Extends limiting picture of hard hexagons.
- Loop gas provides good rationalization as long as other states can be neglected (2,3).
- Experimentally relevant for e.g. Cd-kapellasite (4).

(1) J. Schnack, J. Schulenburg, A. Honecker, J. Richter, Phys. Rev. Lett. **125**, 117207 (2020)
(2) A. Honecker, J. Richter, J. Schnack, A. Wietek, Cond. Matter Phys. **23**, 43712 (2020)
(3) https://perso.u-cergy.fr/ ahonecker/talks/kagomeLoop15december2020.pdf
(4) R. Okuma, D. Nakamura, T. Okubo, A. Miyake, A. Matsuo, K. Kindo, M. Tokunaga, N. Kawashima, S. Takeyama, and Z. Hiroi, Nat. Commun. **10**, 1229 (2019)

Thank you very much for your attention.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Johannes Richer


Jörg Schulenburg


Jürgen Schnack

The end.