# Fundamental properties of frustrated magnetic systems

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# Proposed result:

• The source of the anomalous behavior of the specific heat capacity in geometrically frustrated magnetic systems was identified at a fundamental level of exactly solvable models.

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# Publications:

- E. Jurčišinová, M. Jurčišin, Multipeak low-temperature behavior of specific heat capacity in frustrated magnetic systems: An exact theoretical analysis, Physical Review E 97 (2018) 052129 (16 pages).
- E. Jurčišinová, M. Jurčišin, *Highly macroscopically degenerated* single-point ground states as source of specific heat capacity anomalies in magnetic frustrated systems, Journal of Magnetism and Magnetic Materials 451 (2018) 137 (6 pages).
- E. Jurčišinová, M. Jurčišin, Antiferromagnetic geometric frustration under the influence of the next-nearest-neighbor interaction. An exactly solvable model, Physica A 492 (2018) 1798 (25 pages).
- A. Bobák, E. Jurčišinová, M. Jurčišin, M. Žukovič, *Frustrated spin-1/2 Ising antiferromagnet on a square lattice in a transverse field*, Physical Review E 97 (2018) 022124 (7 pages).

## • Physical Review E 97 (2018) 052129

#### PHYSICAL REVIEW E 97, 052129 (2018)

#### Multipeak low-temperature behavior of specific heat capacity in frustrated magnetic systems: An exact theoretical analysis

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We investigate in detail the process of formation of the multipeak low-temperature structure in the behavior of the encode the executive bar accessive in furstand magnetic systems in the framework of the extend synaphar differomagnetic system in the framework of the extend synaphar differomagnetic system in the framework of the extend synaphar differomagnetic system in the behavior of the multistic interaction in the presence of the extend an magnetic field on the kagome-like like simulation. Extend structure values of the residual entropies of all ground states are found. It is shown that the multipeak structure in the behavior of the models is related to the formation of the multipeed birarchical ordering in the system of all ground states of the mudel. Direct relation between the maximal number of peaks in the specific heat capacity behavior and the number of independent interactions in studied frametated magnetic system is identified. The mechanism of the formation of the multipeak structure in the specific heat capacity is described and studied in detail, and it is generalized to finantiated magnetic systems via the altright.

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**Research** articles

Highly macroscopically degenerated single-point ground states as source of specific heat capacity anomalies in magnetic frustrated systems



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#### ABSTRACT

Anomalies of the specific heat capacity are investigated in the framework of the exactly solvable antiferromagnetic spin-1/2 Ising model in the external magnetic field on the geometrically frustrated tetrahedron recursive lattice. It is shown that the Schottly-type anomaly in the behavior of the specific heat capacity is related to the existence of unique highly macroscopically degenerated single-point ground states which are formed on the borders between neighboring plateau-like ground states. It is also shown that the very existence of these single-point ground states with large residual entropies predicts the appearance of another anomaly in the behavior of the specific heat capacity for low temperatures, namely, the field-induced double-peak structure, which exists, and should be observed experimentally, along with the Schottly-type anomaly in various frustrated magnetic, system.

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#### Antiferromagnetic geometric frustration under the influence of the next-nearest-neighbor interaction. An exactly solvable model



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## • Physica A 492 (2018) 1798

• Ground states properties in H/|J| vs  $\alpha$  plane;



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## •Physical Review E 97 (2018) 022124

#### PHYSICAL REVIEW E 97, 022124 (2018)

#### Frustrated spin-<sup>1</sup>/<sub>2</sub> Ising antiferromagnet on a square lattice in a transverse field

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We investigate the phase transitions and tricritical behaviors of the frustrated Ising antiferromagnet with first-( $J_1 < 0$ ) and second-( $J_2 < 0$ ) nearest-neighbor interactions in a transverse field  $\Omega$  on the square latice using an effective-field theory with correlations based on a single-spin approximation. We have proposed a functional for the free energy to obtain the phase diagram in the T - R ( $R = J_2/|J_1|$ ) or  $T - \Omega$  planes. It is shown that due to the transverse field the phase transition between ordered and disordered phases changes in the tricritical point (TCP) from the second order to the first order. The longitudinal and transverse magnetizations are also studied for selected values of R and  $\Omega$ . In particular, the variation of TCP at the ground state in the three-dimensional space is constructed. For some special cases, values of the critical temperature and the critical transverse field have been determined analytically.

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## • Main results

- General unambiguous classification of sets of all ground states of frustrated magnetic systems is introduced.
- The residual entropy hierarchy s<sub>i</sub> ≥ s<sub>j</sub> between any pair of neighboring ground states of different orders i < j must be valid to avoid violation of thermodynamic principles.
- Direct relation between the maximal number of peaks in the temperature dependence of the specific heat capacity and the dimension of the parametric space of the model is established.
- The maximal possible number of peaks of the specific heat capacity is realized only when there exists at least one strict  $(s_i > s_j)$  entropy hierarchy among residual entropies of neighboring ground states of all orders.
- The necessity of the formation of the low-temperatures field-induced sharp double-peaks in the behavior specific heat capacity as the function of the external magnetic field is demonstrated.

#### • Main results

- Possible existence of the ground states with the same value of the magnetization but different values of the residual entropies is demonstrated.
- The fact that the transversal field suppresses *tricritical* behavior in frustrated magnetic systems is demonstrated.

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## Thank you for attention

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