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Short-range interacting system without additivity

Takashi Mori
The University of Tokyo

Additivity is a fundamental concept of thermodynamics and statistical physics. Roughly speaking, if the total amount of energy is given by sum of internal energies of the macroscopic subsystems, the system is said to be additive. Additivity ensures the convexity or concavity of thermodynamic functions and the ensemble equivalence.

A short-range interacting system is unlikely to be nonadditive since the interaction energy between subsystems is typically very small compared to the bulk energy. In this talk, however, we present a short-range interacting model on the two-dimensional lattice without additivity [1]. This model is referred to as the "elastic spin model", which was originally introduced as a theoretical model of spin-crossover transitions [2].

The essential point is the separation of several timescales, and hence, strictly speaking, nonadditivity emerges when the system is not in genuine thermal equilibrium but in a long-lived "prethermalized" state, which is described by equilibrium statistical mechanics of a nonlocal effective Hamiltonian.

An interesting feature is that the elastic spin model is nonadditive but, nevertheless, extensive. Nonadditivity and extensivity are directly confirmed by the work measurements in the thermodynamic process to divide the system into two macroscopic subsystems. We also find that the several statistical ensembles are not equivalent; e.g. negative specific heats are observed numerically.

[1] T. Mori, arXiv:1301.1422
[2] M. Nishino, K. Boukheddaden, Y. Konishi, and S. Miyashita, Phys. Rev. Lett. **98**, 247203 (2007)