Finite size scaling for a mean-field kinetically constrained model: dynamical glassiness and quantum criticality

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Kinetically constrained models (KCMs) are known as the models whose dynamics shares features similar to those of glassy phenomena. It was recently found that the dynamical free energy, which was defined on the trajectories of the KCMs, showed a first-order phase transition [1]. For dynamical free energies defined on general Markovian processes, an equality similar to thermodynamic relations was confirmed, where a variational principle played a key role to characterize the "thermodynamic" state [2]. This formulation allows us to discuss the dynamical phase transition from the viewpoint of the (well-known) thermodynamics. Here, we ask if there exist similar structures between the dynamical phase transition and the thermodynamic phase transition. Especially, we consider a mean-field Fredrickson-Andersen model, and focus on the finite-size properties around the transition point. The main results are (i) similar to thermodynamic first order phase transition, there is a scaling function around the transition point, and (ii) by using the variational principle [2], which has never appeared in thermodynamics, we propose an ansatz to obtain the analytical expression of the scaling function.

At the same time, we also consider the problems of quantum phase transition. There is a mapping of the dynamical free energy defined on equilibrium systems to the ground state energy of quantum systems. Since it has been found a lot of results for the time-series statistics, including the fluctuation theorem, it will be fruitful to utilize them for the analysis of the quantum phase transition. Especially, we consider a mean-field quantum ferromagnet, and discuss the usability of the population dynamics and our method to determine the scaling function. We also discuss the general relationship between the dynamical glassiness and the quantum criticality.

[1] J. P. Garrahan, R. L. Jack, V. Lecomte, E. Pitard, K. van Duijvendijk and F. van Wijland, Phys. Rev. Lett. **98** 195702 (2007).
[2] T. Nemoto and S.-I. Sasa, Phys. Rev. E **84**, 061113 (2011).