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Physical properties of thermal pure quantum state

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A thermal equilibrium state of a quantum many-body system can be represented by a typical pure state, which we call a thermal pure quantum (TPQ) state. We have found the microcanonical TPQ state, which corresponds to the microcanonical ensemble of the conventional statistical mechanics [1], and the canonical TPQ state, which corresponds to the canonical ensemble [2]. The TPQ states corresponding to other ensembles can also be constructed. These TPQ states give identical thermodynamic results, if both ensembles do, in the thermodynamic limit. We have thus established the TPQ formulation of statistical mechanics, according to which all quantities of statistical-mechanical interest are obtained from a single realization of either TPQ state. In this talk, we discuss physical aspects of the TPQ states. We will show that cumulant generating functions and dynamical correlations are also given by a single realization of TPQ state. Namely, their values converge in probability to the correct result. We will also show that TPQ states have exponentially large entanglement, while the density matrices which represents the equilibrium state in ensemble formulation have much less entanglement.

[1] S. Sugiura and A. Shimizu, Phys. Rev. Lett. **108**, 240401 (2012).
[2] S. Sugiura and A. Shimizu, arXiv:1302.3138