Large deviation implies First and Second Laws of Thermodynamics

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To reconstruct thermodynamics based on the microscopic laws is one of the most important goals of statistical physics. Here, we show [1] that the first law and the second law for adiabatic processes are derived from a natural assumption that "probability distributions of energy in Gibbs states satisfy the large deviation principle," which is widely accepted as a property of thermodynamic equilibrium states.
As a starting point of discussions, we define an adiabatic transformation on thermodynamic systems as a randomized energy-preserving unitary transformation over the many-body systems and the external work storage, where the many-body systems are initially in a set of Gibbs states.
As the second law, we show the principle of the entropy increase. Namely, we show that an adiabatic transformation from the initial state (a set of Gibbs states) to the final state (another set of Gibbs states) is possible if and only if the regularized von Neumann entropy of the final state is larger than or equal to that of the initial state.
As the first law, we show that the difference of energy in the many-body systems before and after the adiabatic transformation is stored in the work storage as "work" in the following sense:
(i) the energy of the work storage takes certain values macroscopically in the initial state and the final state.
(ii) the entropy of the work storage does not change macroscopically before and after the process.
As corollaries of the above results, we also give other forms of first and second laws of thermodynamics, e.g., the principle of maximam work and the first law for the isothermal processes. The more detailed background, formulation, result and derivation are given in arXiv manuscript arXiv:1611.06614.

[1] H. Tajima, E. Wakakuwa and T. Ogawa, arXiv:1611.06614 (2016).