

Quantum counterpart of energy equipartition theorem - General case

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In classical statistical physics, the theorem on equipartition of kinetic energy is one of the most universal relation. It states that for a system in thermodynamic equilibrium of temperature T , the mean kinetic energy E_k per one degree of freedom is equal to $E_k = k_B T / 2$, where k_B is the Boltzmann constant. On the contrary, for quantum systems, the mean kinetic energy is not equally shared among all degrees of freedom and the theorem fails. The quite natural question arises whether one can formulate a similar and universal relation for the mean kinetic energy of quantum systems at the thermodynamic equilibrium state. Recently [1], the quantum analogue of the classical energy equipartition theorem has been proved in a general case. The proof is based on the fluctuation-dissipation relation of the Callen-Welton type. The quantum analogue is also universal in the sense that it holds true for all quantum systems which are composed of an arbitrary number of non-interacting or interacting particles, subjected to any confining potentials and coupled to thermostat with arbitrary coupling strength (from weak-coupling to strong coupling regimes) as well as for arbitrary temperatures.

[1] J. Łuczka, J. Stat. Phys. 179 (2020) 839.