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Energy conservation, return to equilibrium and modular theory

Using methods of spectral analysis and modular theory of operator algebras, we study the energy transfers between a small system $\mathcal{S}$ and a reservoir $\mathcal{R}$ in the process of return to equilibrium. More precisely, we consider a microscopic Hamiltonian model describing a finite level quantum system S coupled to an infinitely extended thermal reservoir $\mathcal{R}$ at inverse temperature β, where the coupling strength depend on a constant λ. We consider the measures $P_{S,\lambda,t}$ and $P_{R,\lambda,t}$ obtained through a two measurement protocol at times 0 and t, for fixed λ. Assuming that the coupled system is mixing, we can show that in a suitable limit regime for λ and t, the limiting measures coincide. This result strengthens the first law of thermodynamics for open quantum systems, which is a statement concerning only the averages of $P_{S,\lambda,t}$ and $P_{R,\lambda,t}$ (joint work with V. Jaksic, J. Panangaden, C-A. Pillet).