Energy conservation, counting statistics and return to equilibrium

Abstract. We study a microscopic Hamiltonian model describing a finite level quantum system $\mathcal{S}$ coupled to an infinitely extended thermal reservoir $\mathcal{R}$. Initially, the system $\mathcal{S}$ is in an arbitrary state while the reservoir is in thermal equilibrium at inverse temperature β. Assuming that the coupled system $\mathcal{S}+\mathcal{R}$ is mixing with respect to the joint thermal state, we study the Full Counting Statistics (FCS) of the energy transfers $\mathcal{S}\to\mathcal{R}$ and $\mathcal{R}\to\mathcal{S}$ in the process of return to equilibrium. The first FCS is an atomic probability measure $\mathbb{P}_{\mathcal{S},\lambda,t}$ concentrated on the set of energy differences $\mathrm{sp}(H_{\mathcal{S}})-\mathrm{sp}(H_{\mathcal{S}})$ ($H_{\mathcal{S}}$ is the Hamiltonian of $\mathcal{S}$, t is time at which the measurement of the energy transfer is performed, and λ is the coupling constant describing the strength of the interaction between $\mathcal{S}$ and $\mathcal{R}$). The second FCS $\mathbb{P}_{\mathcal{R},\lambda,t}$ is typically a continuous probability measure whose support is the whole real line. We study the large time limit $t\to\infty$ of these two measures followed by the weak coupling limit $\lambda\to 0$ and prove that the limiting measures coincide. This result strengthens the first law of thermodynamics for open quantum systems. The proofs are based on modular theory of operator algebras and quantum transfer operator representation of FCS. (joint work with V. Jakšić, J. Panangaden, C-A. Pillet)