Full-counting statistics of information content and the optimum capacity

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Through a mesoscopic quantum conductor, one bit of information content can be conveyed by the arrival or non-arrival of an electron. The performance of communication through such conductor is limited by laws of physics and has been discussed since 1960s. The optimum channel capacity, the maximum rate at which information can be transmitted under a given signal power, i.e. heat current, relates the theory of communication, thermodynamics and quantum physics. We revisit this issue by considering a bipartite quantum conductor and analyzing fluctuations of self-information associated with the reduced density matrix of a subsystem subjected to a constraint of the local heat quantity [1]. The operator of the self-information introduced in this way may be formally regarded as the entanglement Hamiltonian. By exploiting the multi-contour Keldysh technique [2,3], we calculate the Renyi entropy, or the infor-mation generating function, from which the probability distribution of the conditional self-information is derived. We present a Jarzynski-equality like universal relation, that relates the optimum capacity, the Renyi entropy of order 0, which is the number of eigenvalues of the entanglement Hamiltonian, and the number of integer partitions into different positive integers. We apply our theory to a two terminal quantum dot and analyze the probability distributions. We point out that at the steady state, the reduced density matrix and the operator of the local heat quantity of the subsystem may be commutative.

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