Quantum computational approach based on quantum κ-entropy

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A novel approach to the quantum version of κ-entropy that incorporates it into the conceptual, mathematical and operational framework of Quantum Computation is put forward. Various alternative expressions stemming from its definition emphasizing, computational and algorithmic aspects are worked out. For the case of canonical Gibbs states is first shown that the κ-entropy can be cast in the form of a expectation value for an observable that is determined. Further an operational method named, the two-temperatures protocol, is introduced that provides a way to obtain the κ-entropy in terms of the partition functions of two auxiliary Gibbs states with temperatures κ-shifted above, the hot-system, and κ-shifted below, the cold-system, with respect to the temperature of initial system. That protocol provides physical procedures for evaluating the entropy for any κ and density matrix. Two novel additional ways of expressing the κ-entropy are introduced. Firstly one determined by a non-negativity definite quantum channel, with Kraus like operator sum representation and its extension to a unitary dilation via a qubit ancilla. Secondly one given as simulation of κ-entropy via the quantum circuit of a generalized version of Hadamard test. Next a simple inter-relation of von Neumann entropy and quantum κ-entropy is worked out and a bound of their difference is evaluated and interpreted. Finally the effect on κ-entropy of quantum noise, implemented as a random unitary quantum channel acting in system's density matrix, is addressed and a bound on entropy's value depending on spectral properties of the noisy channel and system's density matrix is evaluated. The results obtained amount to a quantum computational tool-box for κ-entropy that enhances its applicability in practical problems as will be outlined.