κ-Entropy: A Quantum Computation and Simulation Approach

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A novel approach to the quantum version of κ-entropy that incorporates it into the conceptual, operational and simulational framework of Quantum Computation is put forward. Various alternative expressions stemming from its definition emphasizing, simulation and algorithmic aspects are worked out. First, for the case of canonical Gibbs states the κ-entropy is determined via an operational method named, - the two-temperatures protocol -, that provides ways to obtain κ-entropy in terms of the partition functions of two auxiliary Gibbs states with temperatures kappa-shifted above and below with respect to original system temperature. That protocol provides physical procedures for evaluating entropy for any kappa. Second, novel ways of expressing κ-entropy are introduced. 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 is shown. Another given as simulation of κ-entropy via the quantum circuit of a generalized version of the so called Hadamard test. A simple inter-relation between von Neumann entropy and κ-entropy is worked out and a bound of their difference is evaluated and interpreted. 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, 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. The approach intents to promote the use the quantum simulation of κ-entropy in quantum as well as classical problems where features and properties of classical systems invoke the need of using κ-entropy in tasks of computation and quantum simulation.

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