Abstract

In this work we construct Kraus operators for various channels via the Choi isomorphism, and study their various properties. The studied channels include those associated with dissipative and non-dissipative interactions, and with the *Unruh effect*. An application of dissipative noise to cryptography is considered. A canonical set of Kraus operators for a channel can be constructed by diagonalizing the *Choi* matrix. In general, analytical diagonalization will fail for higher dimensions greater than 4 because of the Abel-Galois no-go theorem of arithmetic. In such conditions, one may resort to numerical Kraus operators, which however offer no advantage over a (numerical) integral solution to the master equation. Here we propose the operator sum-difference representation, which circumvents this obstacle, essentially by expressing the Choi matrix for the channel as a sum of Hermitian matrices that are of sufficiently low-degree as to be analytically diagonalizable and thereby amenable to a Kraus-like representation. Some of the operators in the representation may appear with a negative sign, hence the name 'operator sum-*difference* representation'. Our method is applicable to general Hermitian (completely-positive or non-completely-positive) maps, and can be extended to the more general, linear maps.

Next we turn our attention to using quantum error correction techniques for characterizing quantum noise. We introduce a novel class of stabilizer codes for which the correctable errors form a group, and which can thus correct arbitrary errors on the qubits of a known subsystem. We propose a quantum process tomography technique, 'quantum error correcting code based characterization of quantum dynamics' (QECCD), which employs these codes to characterize the unknown quantum dynamics acting on the subsystem. This permits an *online* characterization of quantum dynamics, in that arbitrary logical states in the code space of the stabilizer code, that may appear during fault tolerant quantum computation, can be used for concurrent characterization of noise.

A quantum error correcting code determines a subspace $\mathcal{C}$ such that allowed errors

can be corrected by a fixed recovery operation. When the recovered state is only required to error-free up to a logical Pauli operation within code space $\mathcal{C}$, we obtain an ambiguous stabilizer code (ASC). This new type of stabilizer code introduced by us, generalizes the concept of a degenerate code, which is the special case where the only residual logical operation after recovery is the trivial one. An ASC cannot be used for error correction, or even, strictly speaking, for error detection. The motivation for introducing ASCs is the characterization of quantum dynamics. In comparison to QECCD, the present method using ASCs requires a smaller size of quantum states. This can be helpful from an experimental perspective, inspite of the cost of increased number of operations.