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Encoding a qubit into multilevel subspaces MATTHEW GRACE, CONSTANTIN BRIF, HERSCHEL RABITZ, Department of Chemistry, Princeton University, Princeton, NJ 08544, IAN WALMSLEY, Department of Physics, University of Oxford, Oxford OX1 3PU, UK, ROBERT KOSUT, SC Solutions, Inc., 1261 Oakmead Parkway, Sunnyvale, CA 94085, DANIEL LIDAR, Department of Chemistry, University of Toronto, Toronto, Ontario, M5S 3H6, Canada — We present a formalism for encoding the logical states of a qubit into subspaces of multiple physical levels. The need for multilevel encoding arises naturally in situations where the speed of quantum operations exceeds the limits imposed by the addressability of individual energy levels of the qubit physical system. The basic feature of the multilevel encoding formalism is the logical equivalence of different physical states and, correspondingly, of different physical transformations. This logical equivalence is a source of a significant flexibility in designing unitary quantum-logic transformations. The multilevel structure inherently accommodates fast and intense broadband controls thereby facilitating faster quantum-gate operations. Another extremely important practical advantage of multilevel encoding is the ability to maintain full quantum-computational fidelity in the presence of mixing and decoherence within logical subspaces. The formalism is developed in detail for single-qubit operations and generalized for two-qubit and multiple-qubit gates.

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