Quantum Error Correction Codes with Spin-Qudits

Javier Oliva del Moral
Josu Etxezarreta Martinez, Antonio deMarti iOlius and Pedro M. Crespo

Department of Basic Sciences, Tecnun – University of Navarra, 20018 San Sebastian, Spain

jolivam@unav.es

Quantum Error Correction Codes (QECCs) are designed to protect information inside a quantum information state, i.e. to protect qubits from decoherence. Many QECCs have been proposed; commonly, they protect logical state of qubits by codifying their information into a larger number of qubits. Stabilizer codes are an example of QECCs where the quantum information is stored in qubits which are eigenstates of a group of Pauli operators. Some examples are the Shor code [1], the Steane code [2] and the 5-qubit code [3], which are able to correct quantum errors of weight 1. We are studying the possibility of preserving the information of a logical qubit by codifying it in a qudit, a quantum information state whose dimension of the Hilbert space (d) is larger than 2, furthermore, we compare it with the aforementioned stabilizer codes with qubits. Codifying a qubit on a qudit has some advantages such as reducing the number of physical systems and the dimension of the Hilbert Space needed to protect it, among others. The Gottesman-Kitaev-Preskill (GKP) code [4] uses bosonic qudits, particles with integer spin, to store and protect quantum information. However, we are focusing on fermionic spin-qudits codes; previous works in this field have studied how to encode a qubit in a 3/2-spin qudit, with a code that is able to correct Z errors of weight 1. In addition, in [5] they proposed a 7/2-spin qudit to correct all Pauli errors of weight 1, whose quantum circuit is represented in Figure 1.

References

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Figure 1

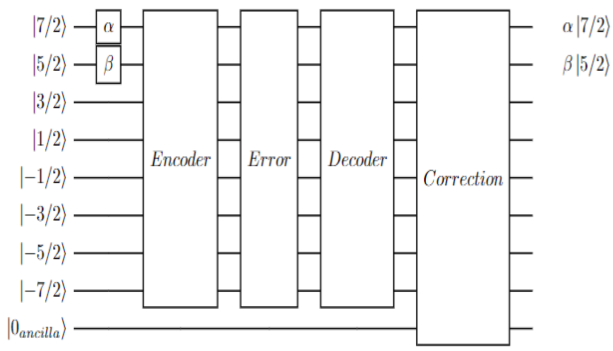

Figure 1: Quantum circuit of a QECC with a Spin-7/2 qudit and one ancilla qubit.