Karlsruhe Institute of Technology

Communications Engineering Lab (CEL)
Prof. Dr.-Ing. Laurent Schmalen
Prof. Dr.-Ing. Peter Rost

CEL

Construction of Finite Length Quantum Error Correcting Codes

Bachelorarbeit/Masterarbeit

Projekt

Quantum computing is an emerging technology that has attracted significant research and industrial interest due to its potential to solve certain computational problems that are believed to be intractable classically. Quantum error correction is one of the most critical components in the realization of practical, large-scale quantum computers. The construction of quantum error-correcting codes can often be reduced to the problem of designing classical linear codes with specific self-orthogonality constraints. Quantum low-density parity-check (QLDPC) codes are particularly promising candidates, as their sparse structure makes them well-suited for practical implementation on quantum hardware.

In recent years, significant progress has been made in the development of high-performance QLDPC codes. Nevertheless, many open problems remain, as quantum memory imposes stringent and often competing requirements on error-correcting codes that must be satisfied simultaneously to enable reliable, large-scale quantum computation. In our previous works [1][2], we have constructed QLDPC codes equipped with an efficient decoding algorithm. In this thesis, we will explore some potential code constructions from both theoretical analysis and numerical simulations.

[1] S. Miao, J. Mandelbaum, H. Jäkel and L. Schmalen, "A joint code and belief propagation decoder design for quantum LDPC codes," Proc. IEEE Int. Symp. Inform. Theory (ISIT), Athens, Greece, Jul. 2024.
[2] A. Baldelli, M. Battaglioni, J. Mandelbaum, S. Miao, and L. Schmalen, "Quantum CSS LDPC Codes based on Dyadic Matrices for Belief Propagation-based Decoding". arXiv preprint arXiv:2601.08636. 2026.

Aufgabenstellung

1. Acquiring fundamental knowledge in quantum error correction
2. Understanding and Implementing existing construction methods
3. Evaluation of the constructed codes

Voraussetzungen

- ✔ Good knowledge of channel coding
- ✔ Solid mathematical knowledge in group and field theory
- ✔ Basic skills in programming

Institut

Communications Engineering Lab

Hertzstr. 16
Gebäude 06.45
76187 Karlsruhe
www.cel.kit.edu

Ansprechpartner

M.Sc.
Sisi Miao

Zimmer 110
sisi.miao@kit.edu