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Quantum Error Correction from the Perspective of the Quantum Marginal Problem

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Abstract:
The Quantum Marginal Problem (QMP) addresses the question of whether the given density operators for subsystems of a multipartite quantum system are compatible with a common global quantum state. The Knill-Laflamme conditions for Quantum Error Correction (QEC) can be formulated in terms of constraints on reduced density matrices (marginals), allowing aspects of QEC to be analyzed from the perspective of the QMP.

In my work, I provide an overview of the QMP and QEC. I also discuss the Knill-Laflamme conditions, their implications for reduced density matrices, and their role in linking error correction to marginal compatibility. Finally, I introduce the formulation of this problem, which can be tackled using Semidefinite Programming (SDP).

The aim of this research is to build a unified perspective that connects marginal compatibility to the structure and design of quantum codes. The long-term goal is to explore whether SDP-based methods can be used not only to verify the existence of QEC codes but also to assist in their optimization and construction.

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