

A STUDY OF ENTANGLEMENT IN QUANTUM INFORMATION THEORY

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Abstract

Although the concept of quantum entanglement has been known for about seventy years, it only recently quit the realms of meta-theoretical discussions when it was discovered how entanglement can be exploited to compute and communicate with an unprecedented power. The primary motivation of the work presented in this thesis has been to contribute to the big effort that has been done during the last decade to understand and quantify quantum entanglement. We have developed advanced techniques of linear and multilinear algebra to investigate and classify entangled pure and mixed quantum states, and discussed some novel applications in the field of quantum information theory.

The results presented in this thesis are mainly of interest from a fundamental point of view: entanglement is the characteristic trait of quantum mechanics, the one that enforces its entire departure from classical lines of thought [186]. It is however a real privilege that fundamental research in quantum information theory bears the tools of tomorrow's electrical engineers: the ongoing miniaturization of electronic components will soon reach a scale where quantum mechanical effects play a major role.

The first part of this thesis is devoted to the study of entanglement. Local equivalence classes of multipartite pure and mixed quantum systems are discussed, and different entanglement measures are introduced and compared. The second part is mainly concerned with the problem of transmission and extraction of classical and quantum information through quantum channels. Optimal detection strategies for continuously monitored systems are derived, and we exploit a duality between quantum maps and entangled quantum states to present a unified description of quantum channels. iii