

English abstract:

Quantum theory provides us with a mathematical framework to understand nature at the microscopic level. It explains phenomena that classical physics could not account for. A deeper understanding of these non-classical phenomena (e.g., entanglement and quantum coherence) is not only of a foundational interest, but also paves the way towards potential technological advancements. Developments in the field of quantum information showed that such quantum features help us to perform operational tasks which would be impossible in the framework of classical physics. Therefore, these quantum phenomena can be viewed as resources which help us to go beyond the restrictions imposed by classical physics. Inspired by this, the mathematical framework of quantum resource theories was developed. Each resource theory singles out a particular quantum resource by setting the states which contain no resource as free states. Furthermore, the set of free operations are defined such that they do not generate resource states out of free states. An important problem in any resource theory is to understand how different resources transform into each other under the action of free operations. This problem of state transformation will be the main focus of this thesis. We will start by studying the notion of deterministic transformations, where one aims to achieve a target state without a chance of failure. We will explore the connection between deterministic transformations and the problem of quantification of resources. We will then go further and concentrate on transformations which allow for a probability of failure, and study the fundamental restrictions imposed on the achievable error and the probability of success. Finally we will explore the idea of catalytic transformations, where we allow for an ancillary quantum system which increases the transformation power while remaining invariant in the process. For the resource theory of entanglement, we will give a full solution for this problem when the target state is pure and the initial state is distillable. Finally, we discuss potential applications of catalysis to the problem of sending quantum information through noisy channels.