報告番号	※甲　　　第　　　　号

主　論　文　の　要　旨

論文題目　Quantum resource theories from the viewpoint of statistical decision theory
（統計的決定理論の観点に基づく量子リソース理論）

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論 文 内 容 の 要 旨

Quantum phenomena are treated as resources for various real-world applications in quantum technologies. Comparing resources aims to discover the capability of quantum systems in information processing tasks.

In this thesis, we first studied quantum measurement and quantum incompatibility as resources. We showed that through a resource-theoretic approach, it is possible to compare a family of quantum measurements in terms of the programmable measurement device (PMD), of which users can have temporal freedom in issuing programs to control the device. The temporal setting leads to the necessity of having quantum memory in the PMDs, which bridges the connection of quantum incompatibility and quantum memory. A complete set of convertibility conditions for programmable devices is derived based on quantum state discrimination with post-measurement information game. This game scenario can be utilized as a tool to certify a genuine PMD or a device with genuine quantum memory. As a byproduct, we derived sufficient and necessary conditions for the convertibility between single POVMs (a special case of PMD) through the task of minimum-error state discrimination game.

We then studied general quantum resources through pure mathematical languages by representing quantum resources as complex density matrices and formulate a general resource theory with F-morphisms as the restricted transformation. The convertibility between resources is characterized by whether there exists F-morphisms between complex density matrics or not. The core idea from a resource-theoretic viewpoint is that it is possible to quantify resources without referring to the maximal ones. Moreover, it is enough to compare some of the entropic quantities of resources to ensure the existence of F-morphisms between them. With our resource-theoretic frame, it is possible to derive a sufficient and necessary condition of the transformation between an arbitrary resource and the maximal resource or a reference resource.

The resource-theoretic approach is essentially the core idea of the statistical comparison theory which was developed in mathematical statistics mainly by Blackwell in the 1950s. The main picture of this thesis is inspired and developed from the viewpoint of statistical comparison theory, then extended into quantum statistics based on a game-theoretic approach.