國立中山大學應用數學系
學術演講

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講　題：Quantum information and the related inverse problems

時　間：2025/5/22（Thursday）15:30 ~ 16:30

地　點：理 SC 4009-1 教室

茶　會：14:45

Abstract

In this talk, I invite everyone to put on a mathematical lens and join me on a guided tour through the world of quantum information theory. Our first stop introduces the concept of quantum states, drawing comparisons with classical states—the kind generated by conventional computers. We'll then step into the idea of a quantum channel, also known as a quantum operation, to understand how it transforms a quantum state. Mathematically, quantum states can be viewed as positive definite matrices with trace equaling 1, whereas classical states correspond to diagonal matrices with the same trace condition. A quantum operation, in this context, can be thought of as a unitary transformation acting on these matrices.

After a short break, we'll move on to the second chamber, where the focus shifts to inverse problems related to quantum channel identification. Since quantum channels are modeled as unitary operators, this naturally leads us to cast the identification task as a least squares problem over the space of unitary matrices. This space forms a smooth manifold, making it possible to apply optimization techniques from differential geometry to find the optimal solution.

在本次演講中,我將內容分為兩個部分。第一部分將介紹量子資訊與量子通道的基本概念,並從數學的角度帶大家理解相關的理論。以線性代數的觀點來看,量子資訊可以表示為一個半正定、trace 為 1 的矩陣;而量子通道則可視為作用在量子態上的 unitary operator。

第二部分將聚焦於與之相關的反問題以及一些仍未解決的開放性問題。具體而言,我們假設有一系列量子態通過某個結構未知的量子通道,且我們已知其對應的輸出態。在這樣的情況下,我們能否反推出該未知的量子通道結構?在某些條件下,答案是肯定的。我們將這類問題轉化為一個 least square 問題。由於量子通道可由酉矩陣描述,因此這實質上是一個限制在酉矩陣所構成之 Stiefel manifold 上的最佳化問題。

在這部分,我會介紹我們所提出的方法,這個方法不僅效率高,而且資源消耗低,能有效地重建出那個未知的量子通道結構。如果時間允許,我也將簡要說明我們目前正在進行的

相關研究與延伸問題的討論。

敬　請　公　告！　歡　迎　參　加！

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