Physics Department Dissertation Defense

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A Geometry of Entanglement

We introduce a novel geometric approach to characterize entanglement relations in large quantum systems. Our approach is inspired by Schumacher's singlet state triangle inequality, which used an entropic-based distance to capture the strange properties of entanglement using geometric-based inequalities. Schumacher uses classical entropy and can only describe the geometry of bipartite states. We extend his approach by using von Neumann entropy to create an entanglement monotone that can be generalized for higher dimensional systems. We achieve this by utilizing recent definitions for entropic areas, volumes, and higher dimensional volumes for multipartite which we introduce in this thesis. This enables us to differentiate systems with high quantum correlation from systems with low quantum correlation and differentiate between different types of multi-partite entanglement. It also enable us to describe some of the strange properties of quantum entanglement using simple geometrical inequalities. Our geometrization of entanglement provides new insight into quantum entanglement. Perhaps by constructing well motivated geometrical structures (e.g. relations among areas, volumes ...), a set of trivial geometrical inequalities can reveal some of the complex properties of higher-dimensional entanglement in multi-partite systems. We provide numerous illustrative applications of this approach.