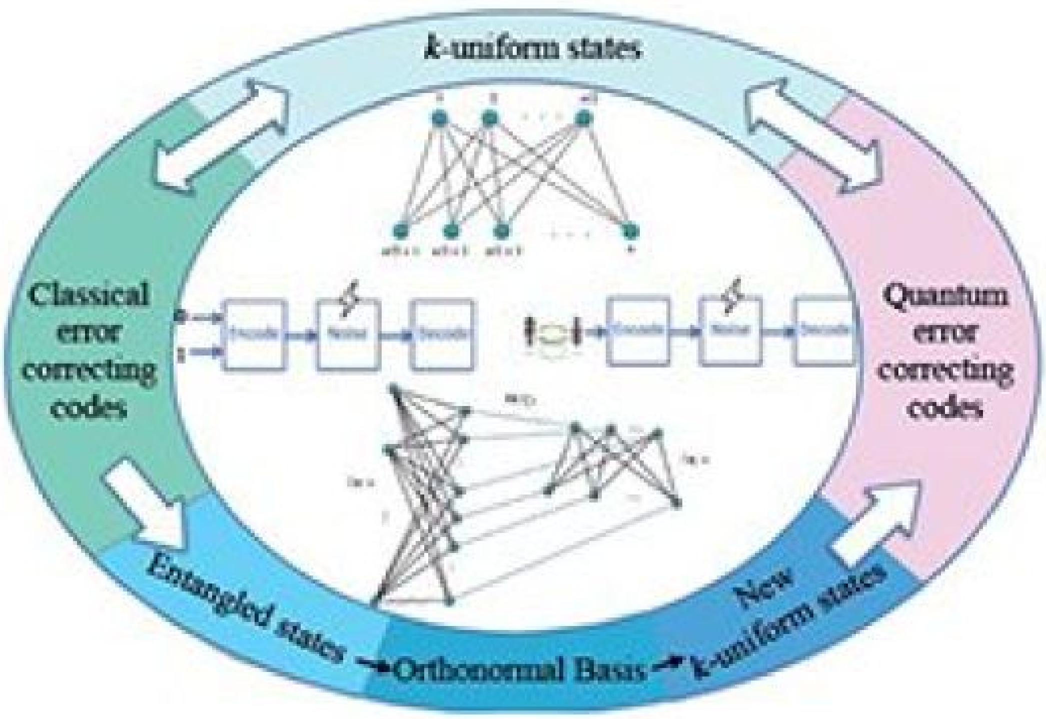

PhD THESIS DEFENSE: Quantum multipartite entangled states, classical and quantum error correction

ZAHRA RAISSI

October 08, 2020

11:00

ICFO Auditorium and Online (Teams)

PhD Thesis Defense

ZAHRA RAISSI

Quantum Information Theory

ICFO-The Institute of Photonic Sciences

Studying entanglement is essential for our understanding of such diverse areas as quantum optics, condensed matter physics and even high energy physics. Moreover, entanglement allows us to surpass classical physics and technologies enabling better information processing, computation, and improved metrology. It was recently discovered that entanglement plays a prominent role in characterizing and simulating quantum many-body states and in this way deepened our understanding of quantum matter. While bipartite pure entangled states are well understood, multipartite entanglement is much richer and leads to stronger contradictions with classical physics. Among all possible entangled states, a special class of states has attracted attention for a wide range of tasks. These states are called k-uniform states and are pure multipartite quantum states of n parties and local dimension q with the property that all of their reductions to k parties are maximally mixed. Operationally, in a k-uniform state any subset of at most k parties is maximally entangled with the rest. The k = [n/2]-uniform states are called absolutely maximally entangled because they are maximally entangled along any splitting of the n parties into two groups. These states find applications in several protocols and, in particular, are the building blocks of quantum error correcting codes with a holographic geometry, which has provided valuable insight into the connections between quantum information theory and conformal field theory. Their properties and the applications are, however, intriguing, as we know little about them: when they exist, how to construct them, how they relate to other multipartite entangled states, such as graph states, or how they connect under local operations and classical communication.

With this motivation in mind, in this thesis we first study the properties of k-uniform states and then present systematic methods to construct closed-form expressions of them. The nature of our methods proves to be particularly fruitful in understanding the structure of these quantum states, their graph-state representation and classification under local operations and classical communication. We also construct several examples of absolutely maximally entangled states, whose existence was a subject of an open question. Finally, we explore a new family of quantum error correcting codes that generalize and improve the link between classical error correcting codes, multipartite entangled states, and the stabilizer formalism.

The results of this thesis can have a role in characterizing and studying the following three topics: multipartite entanglement, classical error correcting codes and quantum error correcting codes. The multipartite entangled states can provide a link to find different resources for quantum information processing tasks and quantify entanglement. Constructing two sets of highly entangled multipartite states, it is important to know if they are equivalent under local operations and classical communication. By understanding which states belong to the same class of quantum resource, one may discuss the role they play in some certain quantum information tasks like quantum key distribution, teleportation and constructing optimum quantum error correcting codes. They can also be used to explore the connection between the Antide Sitter/Conformal Field Theory holographic correspondence and quantum error correction, which will then allow us to construct better quantum error correcting codes. At the same time their roles in the characterization of quantum networks will be essential to design functional networks, robust against losses and local noise.

We strongly support Zahra on this important day of her professional career. Also, we wi h her a very successful presentati

Due to recommendations in place to contribute containing the spreading of COVID-19, th defence will be carried out semi presencial with a maximum of 20 Icfonians in t e Auditorium, and partly remotely via MS Teams. In case you want to receive an invitation to attend the thesis online, you can send an email to me mery.gil@icfo.eu.

If you are interested in attending in person, please address your request to zahra.raissi@icfo.eu or mery.gil@icfo.eu by Monday October 5.

Host: Prof Dr Antonio Acin (Thesis Advisor) and Dr Christian Gogolin (Thesis Co-advisor)

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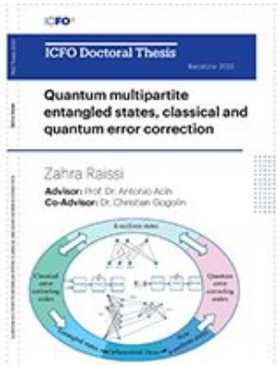

Zahra Raissi's Thesi Cover