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Trustworthy Quantum Information: Highlights and Challenges

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Abstract. The first generation of quantum information applications are *trusted* solutions: when a quantum state needs to be created or a quantum operation needs to be applied, the user simply believes that his/her quantum hardware executes the instructions according to the specifications. The past few years have witnessed the rapid development of a new generation of quantum information applications. They are *trustworthy* in the sense that a quantum device has to prove to the user that it is operating as expected. Trustworthy quantum information enables verification of potentially faulty quantum devices and provides resilience against adversarially prepared quantum devices. These practical motivations often lead to fundamental questions about quantum information. In this talk, I will present some of the highlights in this emerging area and invite the audience to research the many fundamental and challenging open problems.

Quantum error-correction in black holes

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Abstract:: It is commonly believed that quantum information is not lost in a black hole. Instead, it is encoded into non-local degrees of freedom in some clever way; like a quantum error-correcting code. In this talk, I will discuss recent attempts to resolve some paradoxes in quantum gravity by using the theory of quantum error-correction. First, I will introduce a simple toy model of the AdS/CFT correspondence based on tensor networks and demonstrate that the correspondence between the AdS gravity and CFT is indeed a realization of quantum codes. I will then show that the quantum butterfly effect in black holes can be interpreted as non-local encoding of quantum information and can be quantitatively measured by out-of-time ordered correlations. Finally, motivated by the black-hole firewall paradox, I will propose a way of measuring the quantum circuit complexity to decode the Hawking radiation. The talk does not assume prior knowledge on gravity.

Based on joint works with Daniel Harlow, Fernando Pastawski, John Preskill and Daniel Roberts.