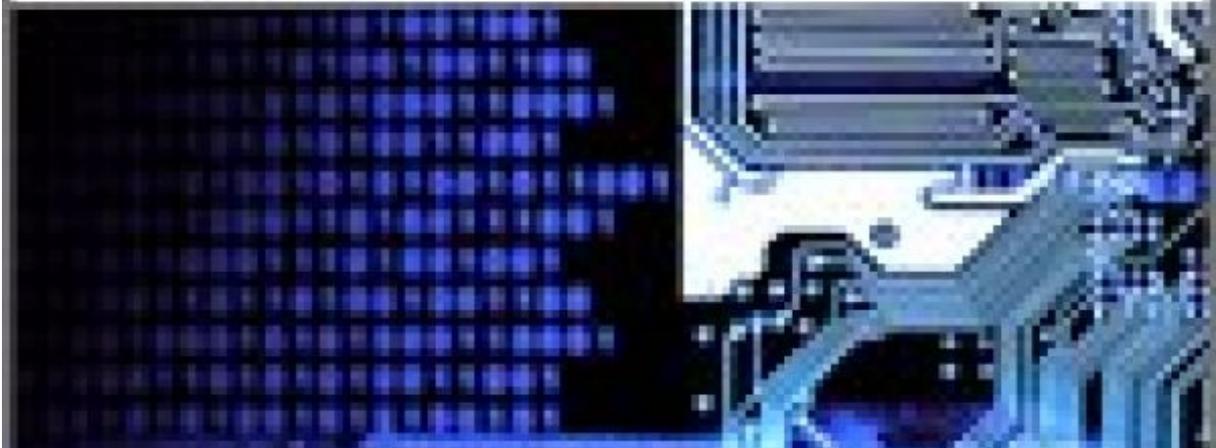**Quantum Resources for Information Processing**

GIUSEPPE PRETTICO

Advisor: Antonio Acín

PhD Thesis Defense GIUSEPPE PRETTICO 'Entanglement And Non-Local Correlations: Quantum Resources For Information Processing'

GIUSEPPE PRETTICO

January 18, 2013

Friday, January 18, 2013, 11:00. ICFO Auditorium

GIUSEPPE PRETTICO

Quantum Optics

ICFO-The Institute of Photonic Sciences, SPAIN

Quantum Information Theory (QIT) studies how information can be processed and transmitted when encoded on quantum states. Practically, it can be understood as the effort to generalize Classical Information Theory to the quantum world. Interestingly, the fact that

very-small scale Physics differs considerably from that of macroscopic objects offers a richer structure to the new theory. Among other phenomena, entanglement is at the heart of many quantum information protocols. It is the most spectacular and counter-intuitive manifestation of quantum mechanics: it signifies the existence of non-local correlations. Although intrinsically non-intuitive, these strange effects have been shown to lead to intriguing applications with no classical analogue.

The main scope of this thesis is to establish qualitative and quantitative connections among the different quantum and classical information resources. Among the many weird effects that quantum systems present, the non-additivity concept plays an important role. In the quantum realm, the joint processing of two quantum resources is often better than the sum of the two resources. Activation is the strongest manifestation of non-additivity. It can be understood as the capability of two objects to achieve a given task that is impossible for each of them when considered individually. From a classical point of view, it is unknown whether such a process can hold. Here we focus on the classical secret-key rate. We provide two probability distributions conjectured to have bound information, hence from which it is conjectured that no secret key can be extracted when taken individually, but that lead to a positive secret-key rate when combined. For that, we exploit the close connection between the information-theoretic key agreement and the quantum entanglement scenario. Successively, we move to the multipartite scenario showing a one-to-one correspondence between bound information and bound entanglement. We provide an example of multipartite bound information which shares the same features of its quantum analogue, the Smolin state. Later, we move to prove a deep connection between privacy and non-locality. We do it by showing that all private states violate the Bell-CHSH inequality. Private states are those entangled states from which a perfectly secure cryptographic key can be extracted. An example of those is the maximally entangled state. But still, there are other private states that are not maximally entangled. While a maximally entangled state violates a Bell's inequality, this is not known a priori for the whole set. We give a general proof valid for any dimension and any number of parties. Private states, then, not only represent the unit of quantum privacy, but also allow two distant parties to establish a different quantum resource, namely non-local correlations. Lastly, we tackle the connection between non-locality and genuine randomness. Non-locality and genuine intrinsic randomness have been the subject of active interest since the early days of quantum physics. Initially, this interest was mainly derived from their foundational and fundamental implications but recently it also has acquired a practical aspect. Recent developments in device independent scenario have heightened the need to quantify both the randomness and non-locality inherent in quantum systems. While some works try to deepen this relation, we provide a simple method to detect Bell tests that

allow the certification of maximal randomness. These arguments exploit the symmetries of Bell inequalities and assume the uniqueness of the quantum probability distribution maximally violating it. We show how these arguments can be applied to intuit the randomness intrinsic in a probability distribution without resorting to numerical calculations.

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