Doctoral Course

Introduction to Quantum Information Theory

Description and objectives

The subject of the course is the Quantum Information Theory, an interdisciplinary area that has acquired an extraordinary development in the last decades. Quantum Information Science essentially investigates on the potential of Quantum Mechanics to generate radically new forms of transmission, storage and processing of the information. This is an introductory course and it is oriented to the foundational, physical and mathematical aspects of the mentioned topics. Students from Physics, Philosophy of Science, Mathematics, Computer Science, Engineer, as well as, any interested in the Quantum realm are welcome. Prior knowledge of Quantum Mechanics and Linear Algebra is helpful, but not required. The main aim of the course is to introduce to the students with the new concepts and methods of Quantum Information Theory, which play a very important role in various areas of current Physics. Also foundational and epistemological aspects will be considered along the course.

Program

Part 1: Foundations of Quantum Mechanics. Review of mathematical formalism (Dirac bra-ket notation). Postulates of quantum mechanics. Quantum states: pure and mixed states. Geometry of Quantum Bits: Bloch sphere. Observables: complementarity and uncertainty. Measurements: projective and generalized measurement. Probabilities: Born's rule. Foundational aspects of superposition, non-locality, entanglement.

Part 2: Composite systems. Global and reduced density operator. Partial trace. Pure and not pure states. Schmidt decomposition. Purification. LOCC paradigm. Definition of entanglement for pure and mixed states. Quantum entanglement measures. Implications and applications of quantum entanglement. Bell inequalities. Separability criteria for non-pure states. Partial positive transposition. Classical and Quantum Correlations: Quantum Discord.

Part 3. Basics of Quantum Computing. Basics Quantum Circuits. Matrix representation of basic operations. Universal quantum gates. Quantum Algorithms (Quantum Teleportation, super dense coding, Grover's search algorithm, etc).

Chronogram

11 lessons of 3hs each. Starting on 1 April, 2020 and continues every Wednesday until 3 June, 2020. Schedule to be agreed with those interested.

Bibliography

M. Nielsen, I. Chuang, *Quantum computation and quantum information*, Cambridge University Press (2000).

I. Bengtsson, K. Życzkowski, *Geometry of Quantum States: An Introduction to Quantum Entanglement*, Cambridge University Press (2017).

J. Watrous, *The Theory of Quantum Information*, Cambridge University Press (2018).

Professor (short CV and description)

Gustavo Martin Bosyk. I come from Buenos Aires, Argentina. I am adjoint researcher at Instituto de Física La Plata – CONICET – UNLP. I obtained my degree in Physics at Universidad de Buenos Aires (UBA) in 2010. I defended my PhD Thesis "Beyond Heisenberg. Landau-Pollak and entropic uncertainty relations” in September, 2014 at the Universidad Nacional de La Plata (UNLP). During my PhD, I was involved in research on information-theoretic formulations of the uncertainty principle. My research interests are the foundations of quantum physics and quantum information theory. I have published more than 20 papers on high impact journals on the field (see my google scholar profile). I was assistant teaching in elementary courses of Physics and Mathematics at UBA. At present, I am doing a long research stay at the group Applied Logic, Philosophy and History of Science (ALOPHIS), University of Cagliari.

Contacts

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