Doctoral Course 2021

Title: *Introduction to Quantum Information Theory*

Professor: Dr. Gustavo Martin Bosyk. In addition, it is plan to invite some experts on the field to give some seminars.

Hours: 22hs.

Chronogram: 11 lessons of 2hs. Starting on 3 March, 2021 and continues every Wednesday until 12 May, 2020. Schedule to be agreed with those interested.

Modality: online by using zoom (or equivalent) platform.

Short description and program: 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 physical and mathematical aspects of the mentioned topics. Students from Physics, Mathematics, Computer Science, Engineer, Philosophy of Science, 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.

The program of course is as follows:

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.

Part 2: Composite systems. Global and reduced density operator. Partial trace. Schmidt decomposition. Purification. LOCC paradigm. Definition of inseparability 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).

Preliminary knowledge: it is needed elementary notions of linear algebra and it is preferable (but not necessary) basic notions of quantum mechanics.

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).

Language: English.