Syllabus of MATH/PHYS/CSCE 764 (Quantum Information)

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Meeting information: MWF 9:40-10:30am, in LeConte 315.

Office Hours: MW 4-5:30pm, or by appointment in LeConte 402.

Course content: Quantum information is a very active research area at the intersection mathematics, physics and computer science. It is the study and quantification of the information which is contained in the state of a quantum system, it can be transmitted via quantum evolutions, and it is governed by the laws of quantum mechanics. In this introductory course we will learn the fundamentals of quantum information. We will learn about quantum states, quantum superposition, quantum entanglement, and quantum channels. We will study to what extend the quantum information can be compressed and communicated. We will introduce the von Neumann entropy and study its properties. We will present the Schumacher compression theorem which gives an interpretational meaning to the von Neumann entropy. We will study transmission of information via noisy quantum channnels and study their capacity. For all the notions that we will study, we will also present their classical counterparts and we will draw similarities and differences.

Course objectives: After completion of the course, you will be able to:

- Have fundamental knowledge of quantum information, and be able to formalize basic problems that arize in quantum physics.
- Have good knowledge of quantum entanglement, superposition and measurement.
- Understand several examples of quantum channels and their representations.
- Understand tensor products of Hilbert spaces and operators and understand how they are used to describe composite quantum systems.
- Explain the process of compression of quantum information and the role of the von Neumann entropy in this task.
- Explain the process of communicating classical information via quantum channels, and understand the capacity of the quantum channels.

Textbook: Mark M. Wilde, "Quantum Information Theory" Cambridge University Press, 2nd edition (February 6, 2017). ISBN-13: 978-1107176164. The latest version of the book can be found free of charge online in the website of its author.

Prerequisites: No prerequisite of quantum mechanics is required. The only prerequisites are some materials from undergraduate linear algebra and probability theory. Materials of Linear Algebra that will be commonly used are: finite dimensional vector spaces, linear dependence and independence, matrices as linear maps, eigenvalues and eigenvectors, inverse matrices, the singular value decomposition of a matrix, norms of vectors, inner products, rank and kernel of a matrix, the adjoint and the transpose of a matrix. Materials of Probability Theory that will be commonly used are: sample space, probability distribution, conditional probability, law of total probability.

Grading: The grade will be based on homework assignments. Homework will be given every week and the students will have one week to complete it.