First course handout for PHY-690F
Quantum Dynamics : Computation & Information

The focus of this special topics course will be towards building an overall understanding of many of the recent developments in the field of quantum information and computation, from the quantum dynamics perspective. There will be a scope to delve deeper into the theoretical underpinnings as well as get realistic understanding of the various experimental set-ups.

Course content :

I. Open quantum systems

Module 1: E.M. field quantization, basic elements of quantum optics

Module 2: States of atoms, Jaynes-Cummings Hamiltonian, elementary quantum gates

Module 3: Open-quantum systems and quantum measurements

Module 4: Quantum state and process tomography

II. Formalism of quantum information dynamics

Module 5 : Classes and properties of entanglement entropy, applications to many-body systems.

Module 6 : Entanglement and measures for mixed states.

Module 7 : Quantum thermalization (ETH, trace distance).

Module 8 : Area laws vs. volume laws of entanglement.

III. Applications: Gravity, cryptography, mesoscopic systems

Module 9 : Entanglement entropy in gravity.

Module 10 : Quantum algorithms, topological quantum computing and error correction.

Module 11 : Basics of quantum cryptography and mesoscopic quantum information.

Module 12 : Open directions, various physical systems.

References:

[1] Quantum Computing, a gentle introduction, by E. Rieffel and W. Polak.
[2] Lecture notes by John McGreevy, UCSD, https://mcgreevy.physics.ucsd.edu/f19/2019-239-lectures.pdf.
[3] Lecture notes by Michal Lukin, Harvard University https://129.2.99.175/wp-content/uploads/2014/09/NewNotesByLily.pdf
[4] Introductory quantum optics, Gerry and Knight.
[5] An open systems approach to quantum optics, J. Carmichael

Lectures will be uploaded and made available via mooKIT / course website (TBA).