Syllabus for EC ENGR 279AS – Special Topics: Physics of Quantum Information and Computation

Instructor: Leo Zhou, Boelter Hall 4532K, leoxzhou@ucla.edu
Lectures: Tuesdays and Thursdays, 4-5:50pm, Boelter Hall 5422
Course website: [link TBD]
Description: This course surveys the physical foundations of quantum information science and quantum computation. Emphasizing both theoretical tools and practical implementations, the course bridges fundamental concepts with experimental approaches ranging from quantum optics to condensed matter systems. Topics include quantum bits and operations, entanglement, quantum computation, error correction, and physical systems for implementations.

Grading: Homework (50%) and two rounds of classroom presentations (50%). The presentations will be based on reading current research papers on topics covered by the course. Collaborations in small groups are encouraged, but names of collaborators should be listed on HW sets and title pages of presentations.

Tentative Outline

1. ***Quantum foundations***
   Two level system, pure and mixed states, unitary evolution, quantum measurements, Ramsey spectroscopy, quantum noise, decoherence.
2. ***Quantum entanglement***
   Coupled qubits, measures of entanglement. EPR paradox and Bell's inequality. Preparation of entangled state. Application for precision measurement. Entanglement in many-body systems: efficient representation of entangled states, tensor networks. Entanglement dynamics.
3. ***Quantum computation***
   Overview of quantum algorithms and computational models: gates, circuits, Hamiltonian-based computation, adiabatic algorithm, variational quantum algorithms. Quantum complexity theory and many-body physics.
4. ***Quantum error correction and fault-tolerance***
   Stabilizer formalism. Computation with surface code. LDPC codes. Transversal gates and non-Clifford operations.
5. ***Physical systems for quantum computation***
   Current experimental frontiers: trapped ions, neutral atoms, superconducting qubits, solid state spins, photons.