The Hebrew University of Jerusalem

Syllabus

Quantum Technologies - 77891

Last update 14-02-2021

HU Credits: 4

Degree/Cycle: 2nd degree (Master)

Responsible Department: Physics

Academic year: 0

Semester: 2nd Semester

Teaching Languages: English and Hebrew

Campus: E. Safra

Course/Module Coordinator: Dr. Itay Shomroni

Coordinator Email: itay.shomroni@mail.huji.ac.il

Coordinator Office Hours: Wednesday 14:00-16:00

Teaching Staff:

Dr. Itay Shomroni

Course/Module description:

Quantum manipulations of single particles is getting closer than ever to technological applications.
In this course I will explain the basic ideas and review the candidates for these technologies, in particular I will concentrate on quantum computing with circuit- and cavity-QED, and quantum optomechanics.

Course/Module aims:

Quantum technologies is a new field that advances swiftly. This course will give the students the basic skills of a researcher in the field.

Learning outcomes - On successful completion of this module, students should be able to:

Ability to follow the basic derivations of the field

Attendance requirements(%):

0

Teaching arrangement and method of instruction: Lectures

Course/Module Content:

1. Introduction and overview of emerging quantum technologies
2. Review of the harmonic oscillator: ladder operators, coherent states, coupled oscillators
3. Review of two-level systems: Pauli matrices, Bloch vector, Rabi oscillations
4. Quantum electrodynamics in superconducting circuits: Elementary superconductivity, microwave transmission lines, the Jaynes-Cummings model in circuit QED, resonant and dispersive regimes
5. Dissipation in quantum systems: The density matrix, the Lindblad master equation, applications to harmonic oscillators and two-level systems
6. Bloch equations for two-level systems, T1 and T2 times. Ramsey spectroscopy. Expression of decay rates via quantum noise spectra.
7. Quantum information processing. Quantum simulation, computation and communication. Quantum bits and gates
8. Quantum error correction. The Shor code.
9. Quantum states of the field. The Wigner distribution. Coherent and squeezed states. Quantum state tomography.
10. Wigner distribution reconstruction via parity measurements.

11. Recent developments in circuit QED
12. Optomechanics: Mechanical effects of light. Fluctuation-dissipation theorem. Wiener-Khinchin theorem.
13. Optomechanical equations of motion. Dynamical backaction: cooling and optical spring effects
14. Quantum-limited displacement detection. Imprecision noise and backaction noise. The standard quantum limit. Backaction-evading measurements.
15. Quantum optics with solid-state emitters. Excitons in quantum dots. Nitrogen-vacancy centers in diamond
16. Hybrid quantum systems

Required Reading:
Will be given during the course.

Additional Reading Material:
Will be given during the course.

Course/Module evaluation:
End of year written/oral examination 0 %
Presentation 0 %
Participation in Tutorials 0 %
Project work 50 %
Assignments 50 %
Reports 0 %
Research project 0 %
Quizzes 0 %
Other 0 %

Additional information:
None