The Hebrew University of Jerusalem

Syllabus

Introduction to Open Quantum Systems - 77541

Last update 13-08-2018

HU Credits: *3*

Degree/Cycle: *2nd degree (Master)*

Responsible Department: *Physics*

Academic year: *0*

Semester: *2nd Semester*

Teaching Languages: *English*

Campus: *E. Safra*

Course/Module Coordinator: *Nir Bar-Gill*

Coordinator Email: *bargill@phys.huji.ac.il*

Coordinator Office Hours: *By appointment*

Teaching Staff:

Prof Nir Bar-Gill

<u>Course/Module description:</u>

The course will untroduce the subject of open quantum systems, along with the necessary mathematical tools and fundamental models. We will describe the relation to quantum information processing, decoherence and dynamical control, as well as to current research topics including quantum measurement and quantum dissipative dynamics. The theoretical concepts will be applied to a few realistic physical systems, such as NV centers in diamond and nano-mechanical oscillators.

<u>Course/Module aims:</u>

- *Acquaintance with the field of open quantum systems, and the basic theoretical tools for describing it*
- *Acquaintance with the main models in the field*
- *Acquaintance with relevant physical systems and current research topics in the field, inspiring interest for further in depth studies in the future*

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

- *Understand the basic problems related to the description of open quantum systems, and the existing models for dealing with them*
- *Tackle and understand the behavior of quantum systems interacting with their environment*
- *Relate to the state-of-the-art of research in the field, and identify leading research directions and open questions.*

<u>Attendance requirements(%):</u>

0

Teaching arrangement and method of instruction: frontal classes

<u>Course/Module Content:</u>

1.Closed systems vs open systems
2.Density matrix theory
2.1.Kraus representation theorem
2.2.Lindblad superoperators
2.3.Master equation – Lindblad and Nakajima-Zwanzig
3.Markovian and non-Markovian processes

4.Decoherence and dynamical control
4.1.Spin-boson model
4.2.Caldera-Leggett model
4.3.Dynamical decoupling and spectral filtering
5.Quantum measurement
6.Dissipative quantum dynamics
7.Examples of physical systems
7.1.Atoms coupled to light
7.2.NV centers in diamond
7.3.Nano-mechanical oscillators

Required Reading:
None

Additional Reading Material:

- *H.-P. Breuer, F. Petruccione: The Theory of Open Quantum Systems (Oxford University Press)*
- *H. W. Wiseman, G. J. Milburn: Quantum Measurement and Control (Cambridge University Press)*
- *S. Haroche, J.-M. Raimond: Exploring the Quantum (Cambridge University Press)*
- *C.W. Gardiner and P. Zoller: Quantum Noise (2nd Ed.) (Springer 2000)*

Course/Module evaluation:
End of year written/oral examination 80 %
Presentation 0 %
Participation in Tutorials 0 %
Project work 0 %
Assignments 20 %
Reports 0 %
Research project 0 %
Quizzes 0 %
Other 0 %

Additional information:
In case there's a non-Hebrew speaking student, the course will be given in English.

Third year undergrads can take the course, if they took "Quantum Physics 2".