01.07.2019

Bar-Ilan University

Non-Equilibrium Systems

86-607-01

Lecturer: Dr. Emanuele Dalla Torre

Course type: Lecture

Date: 2019-2020 **semester:** B **weekly hours:** 3

Aim of course:

To describe the physical properties of large systems it is often necessary to apply statistical methods, which allow us to bridge between the microscopic description of an isolated atom and the collective behavior of a large ensemble (matter). Among the primary tools of statistical mechanics, we find the concepts of temperature, entropy, and free energy. These tools rely on the assumption of a Boltzmann distribution and are not valid if the system is driven out of equilibrium, due to the coupling to external time-dependent forces. In this course we will learn how to characterize out-of-equilibrium systems using simple tools, such as the Langevin and the Gross-Pitaevski equations, and more advanced methods, such as Keldysh path integrals. An underlying theme of the course concerns differences and similarities between classical statistics and quantum uncertainty.

Details of subjects to be covered:

1. Bosons:
    a. Bosonic coherent states
    b. Green functions
    c. Closed time contour
    d. Keldysh rotation
2. Single-particle quantum mechanics :
    a. Time-dependent Harmonic oscillator
    b. Dissipation and tunneling
3. Classical stochastic systems:
    a. Langevin equations
    b. MSR method
    c. Fokker-Plank
    d. Colored Noise
4. Bosonic fields
    a. Dyson equation and self-energy
    b. Collision integrals

5. Kinetics of Bose condensates
    a. Gross-Pitaevski
    b. Quasiparticles
    c. Dynamics of a quantum impurity in a condensate
6. Dynamics of phase transitions
    a. Critical dynamics
    b. Hohenberg-Halperin classification

Prerequisites:

Advanced Statistical Mechanics 86-821
Advanced Quantum Theory 86-803
(Recommended: Phase Transition and Critical Phenomena 86-743)

Course mandatories:

Homework and Presentation.

Grading:

Homework 20%
Presentation 20%
Oral exam 60%
Bonus (Participation in class) 10%

Bibliography:

Textbooks (Optional):

A. Kamenev, Field Theory of Non Equilibrium Systems, Cambridge press 2011

H.-P. Breuer and F. Petruccione, The theory of open quantum systems, Oxford University Press 2002

A. Altland and B. Simons, Condensed Matter Field Theory, Cambridge University Press 2010

U. Wiess, Quantum Dissipative Systems, World Scientific Publishing co, 2012