Linnæus University

Jnr: 2015/1654-3.1.2

Course syllabus

Faculty of Technology

Department of Physics and Electrical Engineering

4FY529 Kvantiserade mångpartikelsystem, 7,5 högskolepoäng
Quantum Theory of Manyparticle Systems, 7.5 credits

Main field of study
Physics

Subject Group
Physics

Level of classification
Second Level

Progression
A1F

Date of Ratification
Approved by Faculty of Technology 2015-05-22
The course syllabus is valid from spring semester 2016

Prerequisites
4FY819 Quantum Mechanics II, 7.5 credits and 4FY810 Statistical Physics, 7.5 credits or equivalent.

Objectives

At the end of the course the students:

- should have acquired a knowledge of second quantization and quantum-field theory methods
- should be able to use Green's functions techniques and Feynman diagrams to solve problems involving many-body systems of Fermions and Bosons at zero and finite temperature
- should account for the many-body effects of the electron-electron interactions in the electron gas
- should be knowledgeable on diagrammatic methods in scattering problems involving impurities and electron-phonon coupling.

Content

I. Quantum Field Theory
A. Second Quantization
B. Fields 2
C. Degenerate Electron Gas 3
D. Pictures
E. Green's Functions

II. Diagrammatic Techniques

A. Wick's Theorem 8
B. Example: First-Order Perturbation Theory 9
C. The Linked-Cluster Expansion 9
D. Feynman Diagrams in Momentum Space 9
E. Dyson's Equations

III. Applications of Green's Function Techniques
A. Hartree-Fock Approximation
B. Degerate Electron Gas: Random Phase Approximation

IV. Imaginary-Time Finite Temperature Formalism
A. Statistical Averages
B. Green's Functions
C. Interaction Representation
D. Matsubara Frequencies
E. Noninteracting Systems
F. Wick's Theorem
G. Feynman Diagrams
H. Frequency Sums
I. Dyson's Equations

V. Applications of the Imaginary-Time Formalism
A. Hartree-Fock Approximation
B. Electron Gas
C. Real-Time Green's Functions
D. Plasma Oscillations

VI. Electron-Phonon Interactions
A.The non-interacting phonon system
B.The Electron-Phonon Interaction

VII. dc Conductivities
A. Electrons scattering by Impurities
B. Electrons-Phonon Interactions in Metals

Type of Instruction

The teaching consists of lectures and tutorials.

Students can also register for the "distance" version of the course and follow the course via the internet. IT support and technical information: Email and web connection. Real time and recorded lectures are available on course homepage.

Examination

The course is assessed with the grades A, B, C, D, E, Fx or F.
The grade A constitutes the highest grade on the scale and the remaining grades follow in descending order where the grade E is the lowest grade on the scale that will result in a pass. The grade F means that the student's performance is assessed as fail (i.e. received the grade F).

Assessment of student performance is made through written test and oral examinations and presentation of mandatory assignments.

Reexamination will be offered within six weeks under the regular semester periods.

Course Evaluation

During the course or in close connection to the course, a course evaluation is to be carried out. The result and analysis of the course evaluation are to be communicated to the students who have taken the course and to the students who are to participate in the course the next time it is offered. The course evaluation is carried out anonymously. The compiled report will be filed at the Faculty.

Credit Overlap

This course cannot be part of a degree in combination with another course in which the content fully or partly correspond to the content of this course: 4FY829
Quantum theory of manyparticle systems, 7.5 credits

Other

Grade criteria for the A–F scale are communicated to the student through a special document. The student is to be informed about the grade criteria for the course by the start of the course at the latest.

Required Reading and Additional Study Material

Required Reading and Additional Study Material
Main references

1. A. L. Fetter and J. D. Walecka, "Quantum Theory of Many-Particle Systems", McGraw-Hill, New York (1971).

2. G. D. Mahan, "Many-Particle Physics", Plenum, New York (1990).

3. H. Bruus and K. Flensberg, "Many-Body Quantum Theory in Condensed Matter Physics', Oxford University Press, Oxford, (2004).

4. Class Notes distributed by the instructor.

Other useful references

A. Altland and B.Simon,"Condensed Matter Field Theory", Cambridge University Press (2010).

E. K. U. Gross, E. Runge and O. Heinonen, "Many-Particle Theory", IOP Publishing, Bristol, (1991).

A. A. Abrikosov, L. P. Gorkov and I. E. Dzyaloshinski, "Methods of Quantum Field Theory in Statistical Physics", Dover, New York (1963).

S. Doniach and E. H. Sondheimer, "Green's Functions for Solid State Physicists", Benjamin, Reading, Mass. (1974).

J. W. Negele and H. Orland, "Quantum Many-Particle Systems", Addison-Wesley, Redwood City, CA (1988).

G. Rickayzen, "Green's Functions and Condensed Matter", Academic Press, New York (1980).