Jnr: 2014/2889–3.1.2

Course syllabus

Faculty of Technology

Department of Physics and Electrical Engineering

4FY829 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 2014-09-22
The course syllabus is valid from spring semester 2015

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 Fail (U), Pass (G) or Pass with Distinction (VG).
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.

On request, students may have their credits translated to ECTSmarks.
Such a request must be sent to the examiner before the grading process starts.

Course Evaluation

A course evaluation will be carried out and compiled after the course is completed. The compilation will be presented to the current board as well as to the students and filed.

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).