GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2025-2026

The Theory of Metals: from Path Integrals to Experiment (C004513)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h**

Course offerings in academic year 2025-2026

A (semester 1) English Gent

Lecturers in academic year 2025-2026

Bultinck, Nick WE05 lecturer-in-charge

Offered in the following programmes in 2025-2026	crdts	offering
Master of Science in Physics and Astronomy	6	A
Exchange Programme in Physics and Astronomy (Master's Level)	6	A

Teaching languages

English

Keywords

Quantum mechanics, many-body systems, interacting electrons and bosons

Position of the course

Contents

1 **Basic concepts:** Second quantization. The free Fermi gas and the Fermi surface. The quantum mechanical description of phonons. Semiclassical equations of motion for electrons. Fermi liquid theory and quasi-particles.
2 **Green's functions and path integrals:** Definition of Green's functions, and a discussion of the physical information they contain about quasi-particles. Derivation of the path integral representation of the partition function for interacting electrons and bosons. Derivation of the Feyman rules for perturbative/diagrammatic studies of interacting electron and boson systems (both in imaginary and real time). Applications: An electron in a random potential, and the screening of the Coulomb interaction in a metal.
3 **Interacting electron-phonon systems:** Derivation of the Frohilich Hamiltonian. Mass renormalization of electrons by the interaction with phonons. The instability of a metal towards the formation of a superconductor.
4 **Linear response theory:** The interaction picture and the definition of linear response coefficients. Connection between linear response theory and different experimental probes of quantum many-body systems. Applications: calculation of the tunneling current in a scanning tunneling microscope experiment, and the cross section in a angle-resolved photo-emission experiment. The Kubo formula for the electric conductivity of a quantum many-body system. Diagrammatic derivation of the Drude conductivity.

Initial competences

Quantum mechanics, solid state physics

Final competences

The student can make a connection between the theoretical and quantum mechanical description of interacting electrons and bosons, and experimentally measurable quantities.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Study material

Type: Syllabus

Name: The theory of metals: from path integrals to experiment
Indicative price: Free or paid by faculty
Optional: no
Available on Ufora : Yes
Online Available : Yes
Available in the Library : No
Available through Student Association : No

References

Course content-related study coaching

Assessment moments

end-of-term assessment

Examination methods in case of periodic assessment during the first examination period

Oral assessment, Written assessment open-book

Examination methods in case of periodic assessment during the second examination period

Oral assessment, Written assessment open-book

Examination methods in case of permanent assessment

Possibilities of retake in case of permanent assessment

not applicable

Calculation of the examination mark

Oral assessment of the theory (60%), and written open-book assessment of the exercises (40%).