

## 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 2024-2025**

A (semester 1)

English

Gent

**Lecturers in academic year 2024-2025**

Bultinck, Nick

WE05

lecturer-in-charge

**Offered in the following programmes in 2024-2025**

[Master of Science in Physics and Astronomy](#)

[Exchange Programme in Physics and Astronomy \(Master's Level\)](#)

**crdts**

**offering**

6

A

6

A

**Teaching languages**

English

**Keywords**

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

**Position of the course**

**Contents**

- 1 **Review of free fermions and bosons:** 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.
- 2 **Coherent states and path Integrals:** Derivation of the path integral representation of the partition function for interacting electrons and bosons. Derivation of the Feynman rules for perturbative/diagrammatic studies of interacting electron and boson systems. Application: the Frohlich Hamiltonian and electron-phonon coupling.
- 3 **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 magnetic susceptibility of a metal, calculation of the tunneling density of states, angle-resolved photoemission experiments to 'measure' the Fermi surface.
- 4 **Electron transport theory:** Kubo formula for the electrical conductivity of a many-body system. The role of disorder. Diagrammatic derivation of the Drude conductivity. Electron diffusion.
- 5 **Local magnetic moments:** The Anderson Hamiltonian and the formation of local magnetic moments. The Schrieffer-Wolff transformation. The Kondo effect.

**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%).