Summary
Introduction to the path integral formulation of quantum mechanics. Derivation of the perturbation expansion of Green's functions in terms of Feynman diagrams. Several applications will be presented, including non-perturbative effects, such as tunneling and instantons.

Content
1. Path Integral formalism
   • Introduction
   • Propagators and Green's functions.
   • Fluctuation determinants.
   • Quantum mechanics in imaginary time and statistical mechanics.

2. Perturbation theory
   • Green's functions: definition and general properties
   • Functional methods
   • perturbation theory by Feynman diagrams

3. Semiclassical approximation
   • The semiclassical limit

4. Non perturbative effects
   • reflection and tunneling through a barrier
   • Instantons

5. Interaction with external magnetic field
   • gauge invariance in quantum mechanics
   • Landau levels.
   • Aharonov-Bohm effect.
   • Dirac's magnetic monopole and charge quantization.

Keywords
Learning Prerequisites

Recommended courses
Quantum physics I and II
Quantum Field Theory I

Important concepts to start the course
Solid knowledge and practice of calculus (complex variable) and linear algebra

Learning Outcomes

By the end of the course, the student must be able to:

• Formulate a quantum mechanical problem in terms of a Path integral
• Compute gaussian path integral as determinants
• Express physical quantities in terms of the Green function
• Translate a Feynman diagram into a mathematical expression
• Compute a Feynman diagram
• Compute tunneling rates in simple quantum potentials
• Formulate the quantum theory of an particle interacting with an external electromagnetic field

Transversal skills

• Use a work methodology appropriate to the task.
• Set objectives and design an action plan to reach those objectives.

Teaching methods

Ex cathedra and exercises

Expected student activities

Participation to classes. Solving problem sets during exercise hours.

Assessment methods

Oral final exam

Supervision

Office hours: Yes
Assistants: Yes
Forum: No
Others: Office hours: Wednesday 14-15

Resources

Bibliography

"Path Integrals in Quantum Mechanics, Statistics and Polymer Physics", Hagen Kleinert, World Scientific,
Ressources en bibliothèque

- Quantum Mechanics and Path Integrals
- Modern Quantum Mechanics
- Path Integrals in Quantum Mechanics, Statistics and Polymer Physics
- Path Integral Methods and Applications
- Techniques and applications of path integration
- Aspects of Symmetry

Notes/Handbook

Prof R. Rattazzi: Lecture Notes for Quantum Mechanics IV