EPFL

PHYS-426

Quantum physics IV

Penedones João Miguel

Cursus	Sem.	Type
Ing.-phys	MA2, MA4	Opt.
Physicien	MA2, MA4	Opt.

Language of teaching	English
Credits	6
Session	Summer
Semester	Spring
Exam	Written
Workload	180h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

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

Path integral formalism. Green's function. Determinants. Feynman diagram. Feynman rules. Perturbation theory. Non-perturbative effects. Tunnelling. Instantons. Gauge-invariance.

Learning Prerequisites

Recommended courses

Quantum physics I, II and III
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 a 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 in lectures. Solving problem sets during exercise hours. Critical study of the material.

Assessment methods

Written exam

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

"Quantum Mechanics and Path Integrals" , R.P. Feynman and A.R. Hibbs, McGraw-Hill, 1965.
"Techniques and applications of Path Integration", L.S. Schulman, John Wiley & Sons Inc., 1981.
"Path Integral Methods and Applications", R. MacKenzie, arXiv:quant-ph/0004090.
"Modern Quantum Mechanics", J.J. Sakurai, The Benjamin/Cummings Publishing Company, 1985.
"Aspects of Symmetry", S. Coleman, Cambridge University Press, 1985.

"Path Integrals in Quantum Mechanics, Statistics and Polymer Physics", Hagen Kleinert, World Scientific, 1995.

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

Lecture Notes for Quantum Mechanics IV

Moodle Link

- https://go.epfl.ch/PHYS-426