UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Laboratory of Theoretical Computational Physics

2526-1-F1703Q024

Aims

Knowledge and understanding:
The student will learn the fundamental concepts and the numerical techniques for computing path integrals.

Applying knowledge and understanding:
The student will have to be able to implement in numerical codes the numerical techniques for the computation of path integrals in Quantum Mechanics and Quantum Field Theory.

Making judgments:
The student will develop critical thinking and judgment skills in selecting the most appropriate tool, among those provided during the course, to solve a specific problem.

Communication skills:
The student will be expected to acquire a correct and appropriate scientific language suited to the topics covered in the course.

Learning skills:
The student will be able to deepen their understanding of specific concepts not covered during the course and to independently pursue advanced study using specialized scientific texts.

Contents

Elementary numerical integration, Monte Carlo methods, numerical simulation of simple quantum and statistical systems.

Detailed program

ELEMENTARY NUMERICAL INTEGRATION:

Formulae of Newton-Cotes, Gaussian quadratures, composite integration.

MONTE CARLO METHODS:

Central limit theorem, Monte Carlo, importance sampling, Markov chains, Metropolis algorithm.

NUMERICAL SIMULATIONS:

Implementation of the Metropolis algorithm for the computation of ratios of path integrals for elementary quantum systems.

Definition of the Quantum Chromodynamics (QCD) on the lattice. Numerical computation of the leading contribution to the eta' mass due to the chiral anomaly.

Prerequisites

Mechanics, Quantum mechanics. Basic knowledge of the Unix/Linux operating system and of the C programming language.

Teaching form

Teaching with standard lectures and laboratory activities:
-32 hours of standard lectures delivered in presence;
-88 hours of laboratory sessions carried out in interactive mode in presence;

All activities will take place in the Computational Physics Laboratory "Marco Comi".

Textbook and teaching resource

Numerical Recipes, W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery.

W. Feller, An introduction to probability theory and its application.

M. Creutz, Quarks, gluons and lattices.

M. Creutz, B. Freedman, A statistical approach to quantum mechanics, Annals of Physics 132 (1981) 427.

I. Montvay, and G. Münster, Quantum Fields on a Lattice, Cambridge University Press (1997).

C.B. Lang, and C. Gattringer, Quantum Chromodynamics on the Lattice. An Introductory Presentation (Lecture Notes in Physics 788), Springer-Verlag Berlin Heidelberg (2010).

Semester

First and second semester.

Assessment method

The students must prepare a written report which summarizes the theoretical material of the course and contains a presentation of the results of the numerical simulations. The report will be discussed in an oral exam, during which the knowledge of the course programme will be verified. The final evaluation will take into account of the quality of the numerical implementation of the techniques learned during the course, of the quality of the numerical results obtained, of the knowledge of the program of the course and of the clarity of the oral and the written presentation.
The evaluation of the software, of the data generated and of the written report will guide the final grade.

Office hours

Students may come to my office any time, preferably Friday 14:00-16:00 . If needed, send an e-mail to fix an appointment.

Sustainable Development Goals

QUALITY EDUCATION | INDUSTRY, INNOVATION AND INFRASTRUCTURE