# . – Particles and Fields

## Professor Giuseppe Nardelli

***COURSE AIMS***

The main objective of the course is to introduce students to the second quantization, the field concept and its interpretation in the field of particle physics. The course also introduces spontaneous symmetry breaking in a quantum theory and introduces the main concepts of Feynman Path Integral in quantum mechanics. The first part of the course will provide some mathematical tools to develop the program (tempered distributions).

At the end of the course, students will be able to appreciate the difference between quantum mechanics and quantum field theory, solve simple problems of quantum field theory (free fields) and evaluate simple path integrals in quantum mechanics.

***COURSE CONTENT***

Tempered distributions and main operations. Important distributions, Sokhotski formulas.

Fourier transforms and fundamental solutions of some differential operators.

The transition from quantum mechanics to field theory.

Symmetries and conservation laws (Noether's theorem).

Free scalar fields, Dirac field, electromagnetic field: classical treatment and quantization; physical interpretation and Fock space, causality and two-point functions. Casimir effect. Aharonov-Bohm effect.

Yang Mills fields (classical treatment, overview), global and local spontaneous symmetry breaking.

Applications: Superconductivity. Semi-classical treatment of the standard model (bosonic part).

Introduction of Feynman path integrals: non-relativistic free particle and quadratic potential.

***READING LIST***

L.H. Ryder, *Quantum Field Theory,* Cambridge Univ. Press, 1985.

M. Peskin and D.V. Schroeder, *An introduction to Quantum Field Theory,* Westview, 1995.

K. Huang, *Quantum Field Theory (from operators to path integrals),* J. Wiley and Sons, 2004.

M. Kaku, *Quantum Field Theory: a modern introduction,* Oxford Univ. Press, 1993.

***TEACHING METHOD***

Lectures.

***ASSESSMENT METHOD***

Interview. The interview is designed to ascertain the student’s assimilation of the concepts taught, and will concentrate on the student’s discussion / explanation of several points of the course programme. The grading of the interview will take into account the accuracy of the responses, their logical and methodological rigour, and the effectiveness of the explanation.

***NOTES AND PREREQUISITES***

Depending on the time available, the part regarding the path integrals or the semi-classical treatment of the bosonic part of the standard model may be omitted/shortened.

Students must have basic knowledge of the quantum mechanics, functional analysis and complex analysis. Students of the graduate degree in Mathematics which are interested in the 6 CFU version of the course should contact prof. G. Nardelli to agree on a specific reduced program, depending on the student’s interests.

***STUDENT RECEPTION***

Prof. Giuseppe Nardelli receive students after the lectures in his office.

Further information can be found on the lecturer's webpage at http://docenti.unicatt.it/web/searchByName.do?language=ENG or on the Faculty notice board.