Université Clermont-Auvergne
EUPI
UFR de Physique.

Symmetries in Physics

Master in Fundamental Physics (M2)

The aim of this course is to stress on the importance of Symmetry in Physics from Classical to Quantum ones. After reviewing the main theorems (Noether, Wigner), emphasis is put on symmetries in Quantum Physics.

The main topics of this course are :
Introduction to Group Theory and its Representations; Galilean Symmetry, and the important features of the Discrete Symmetries (Parity and Time-Reversal) in Quantum Physics.
Examples from Atomic and Nuclear Physics will be outlined.

I) Generalities on Symmetry

• Different kinds of Symmetry : Geometrical and Dynamical; Continuous and Discrete.

• Modern approach to Symmetry : Partial (broken) and Exact Symmetry.

• Noether Theorem in Classical Physics : Conservation Laws. Canonical Variables.

II) Galilean Invariance in QM

• Wigner Theorem : Unitary and Anti-Unitary Operators.

• Space-Time Symmetries :
⋆ Active and Passive points of view.
⋆ Galilean transformations.

• Galilean Group and its generators :
⋆ Notion of a Lie roup.
⋆ Physical Aspects of the Galilean group.

III) Group Theory and its Representations

• Basics of Group Theory : Subgroups. Compact Groups. Character of a Group.

• Introduction to the Representation Theory : Matrice Groups. Reducibility.

• Schur's Lemma.

• Applications : Symmetries of the Schrodinger equation.

IV Discrete Symmetries in QM

• Discrete Transformations in Classical Physics : Parity (P) and Time-Reversal (T).
⋆ Applications in Electrodynamics.

• Fundamental aspects of Discrete Transformations in Quantum Mechanics :
⋆ Parity Quantum Number.
⋆ T as Anti-unitary operator.
⋆ Selection rules.

• Transformation of a system with Spin : Kramer's Theorem and its applications.

All the above chapters will be illustrated by many examples coming from physical problems : *Laporte's rule* for radiative decays. *Electric Dipole Moment* and its relation to Time-Reversal violation. Parity Violation.

With my best regards,

Z.J.Ajaltouni