Dipartimento di Fisica e Astronomia “Galileo Galilei” - Università di Padova

Outline of LM course in

Introduction to Quantum ElectroDynamics

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February 28, 2014

The main goal of the course is to offer a basic introduction to relativistic quantum field theory, for graduate students with interest in theoretical and experimental high energy particle physics (students within the theoretical/modeling path are suggested to follow in addition the parallel course “Field Theory I”).

The Langrangian and Hamiltonian description for classical fields will be shortly reviewed, focusing in particular to the relation between the symmetry properties of a physical system and conservation laws.

The quantization for free spin 0, spin 1/2 and spin 1 fields (in the covariant approach) is introduced, through the so called “canonical quantization” procedure. The case of interacting fields is discussed by the introduction of the Scattering matrix formalism. With the aid of Feynman graphs the most relevant Quantum Electro-Dynamics processes at the lowest order can be calculated. A first glimpse on the renormalization problem for QED is also given depending on time.

Regular Lectures Schedule - a.a. 2013/14

Wednesday	11.30–13.15	Aula C
Thursday	8.30–10.15	Aula C
Friday	9.30–11.15	Aula C

Suggested Textbooks

RECOMMENDED as STANDALONE books on QED

× F. Mandl and G. Shaw,
Quantum Field Theory (revised edition),
John Wiley and Sons, 1993;

× M. Maggiore,
A modern Introduction to Quantum Field Theory,
Oxford University Press, 2005;

× R. D'Auria and M. Trigiante,
From Special Relativity to Feynman Diagrams, Springler 2012;

Also SUGGESTED for High Energy Theoretical Curricula

† M.E. Peskin and D.V. Schroeder,
Introduction to Quantum Field Theory,
Addison-Wesley, 1995;

• C. Itzykson and J.B. Zuber,
Quantum Field Theory, McGraw-Hill, 1980;

∗ P. Ramond,
Field Theory: A Modern Primer,
Second Edition, Westview, 1990;

∗ S. Pokorski,
Gauge Field Theories,
Second Edition, Cambridge University Press, 2000;

∗ M. Srednicki,
Quantum Field Theory,
Cambridge University Press, 2007;

× = Recommended for this course;
† = Recommended also by Prof. Feruglio for "Teoria dei Campi I";
∗ = Use mainly path integral approach;

Contents (* = *depending on time availability*)

i) Review on classical field theory with a Lagrangian approach; Eulero-Lagrange equation of motion for classical fields and Noether theorem on conserved quantities;
   - Klein-Gordon equation and spin 0 classical fields;
   - Dirac equation and spin 1/2 classical fields;
   - Maxwell equations and spin 1 classical fields;

ii) Canonical quantization of spin 0 fields:
   - Commutator relations and Fock space for real and complex spin 0 fields;
   - Time evolution and the S matrix;
   - The LSZ reduction formula;
   - Green function and propagator;
   - Wick theorem and Feynman rules for $\lambda\varphi^4$;
   - Classification of higher order diagrams;
   - * Spontaneous symmetry breaking;

iii) Canonical quantization of spin 1/2 fields:
   - Anti-commutator relations and Fock space for spin 1/2 fields;
   - Green function and propagator;
   - Feynman rules for Yukawa interaction;

iv) Canonical quantization of spin 1 fields:
   - Commutator relations and Fock space for spin 1 fields;
   - Gauge invariance and Gupta-Bleuler formalism;
   - Green function and propagator;

v) Abelian gauge theory: SQED and QED
   - Lagrangian for an Abelian gauge theory: SQED and QED;
   - Feynman rules and lowest order Feynman diagrams;
   - Two particle final state: cross section and decay width;

vi) Calculation of QED processes in lowest order
   - Compton and Bahba scattering, etc..

vii) Hints on one loop calculations:
   - * Anomalous magnetic moment of a charged fermion;
   - * Superficial degree of divergence;
   - * One loop divergences, regularization and renormalization;