10674 – 755 (16) Relativistic Quantum Field Theory (3L, 3P)

2020

Course summary:

Module introduces quantum field theory. Lagrange formalism in field theory and Noether currents. Covariant quantization of Klein-Gordon and Dirac fields. Particle interpretation, spin and statistics. Functional calculus, Grassmann variables, functional integral quantizations of gauge theories. Perturbation theory and Feynman rules. Cross-sections and decay widths in particle physics. Effective Potentials. Regularization and renormalization. Asymptotic freedom in gauge theories.

Module relevance in programme:

This is the top end of the quantum mechanics series after P334, P714 and P719. Modern techniques, such as functional calculus, are employed to explore the physics of elementary particles. The module provides instruments to pursue a research project on MSc and/or PhD level in theoretical particle physcis and quantum field theory.

Outcomes of course:

The student will learn the concept of quantized fields, which is the second part of the quantum mechanical solution to the particle-wave-dualism. Covariant field quantization will be used to explain the basic concepts and path integral (functional) techniques will be developed to efficiently quantize gauge theories, the construction principle of the established standard model for particle physics. Finally the successful student will acquire the skills to compute (basic) Feynman diagrams in a given quantum field theory that enter calculations for scattering processes as well as the entries of the renormalization group equations.

Lecturer:

Prof H Weigel
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Mentor:

The Department of Physics has appointed a staff member as mentor for each year of its physics programme to be available to students for consultation. Students should feel free to discuss general issues related to the physics programme or specific modules in the programme with the relevant mentor, in addition to usual consultations with their individual lecturers of modules.

The mentor for the Honours programme and its modules is Dr CM Steenkamp cmsteen@sun.ac.za.

Course content:

Formal lectures

Lagrangian and Noether formalism for fields. Canonical quantization. (Anti)Commutators for fields, Path integrals. Grassman variables. Quantization of gauge fields. Green's functions and scattering

amplitudes. Feynman diagrams. Regularization and renormalization. Renormalization group and asymtotic freedom. Spontaneous symmetry breaking.

Laboratorywork: ***none***

Practical (Tutorials):

Tutorials (3h/week) enable the student to cope with exercises and standard problems.

Study material:

Recommended textbooks:
L. Ryder, Quantum Field Theory, Cambrigde University press (1985),
D. Bailin and A. Love, Introduction to Gauge Field Theory, IOP (1993).

Textbooks whose content goes beyond these lectures to be used as reference:
Quantum Field Theory, C. Itzykson and J.-B. Zuber, Mc Graw Hill, 1980.
Introduction to Quantum Field Theory, M. E. Peskin and D. V. Schroeder, Perseus Books, 1995.

Learning opportunities:

Lectures as indicated on time table
Further information can be traced at http://www.physics.sun.ac.za/~weigel/teach/qft.html

Assessment:

Methods of Assessments
Evaluated on a continuous basis.

Venue and time of assessment opportunities
Set in consultation with the lecturers.

Availability of marks:
As soon as possible

Calculation of final mark for the module:
Test 1 – 25% (3rd quarter)
Test 2 – 25% (4th quarter)
In each quarter homework assignments and self-studies will contribute 25% to the final mark.