ICTP DIPLOMA PROGRAMME IN HIGH ENERGY PHYSICS 2014-15

SYLLABUS

Relativistic Quantum Mechanics - {20 Lectures = 30 hours} E. Gava

Part I

1. **Mathematical Tools for Quantum Mechanics**
   Kets and bras. Inner Products. Linear operators. Hermitian operators and observables. Representations in state space: orthonormal basis, completeness relation, representations of kets and bras, and of operators, change of representation, unitary operators, transformation matrix. Eigenvalue equation and diagonalisation. Definition of observable, commuting observables, unitary equivalent observables, noncommuting observables.

2. **Physical Postulates of Quantum Mechanics**
   Description of the state of the system, physical quantities, measurement of physical quantities, spectral decomposition, probabality interpretation. Expectation values. Heisenberg uncertainty relation. Pure and Mixed States, Density Matrix. Example: the Spin 1/2 system.

3. **Position, Momentum and Translations**
   Continuous spectra, Dirac delta function. Position eigenkets and position measurement. Momentum as generator of infinitesimal translations, in quantum and classical mechanics. Finite translations. Canonical commutation relations. Wave functions in position and momentum space.

4. **Quantum Dynamics**
   Time evolution. The Schrödinger equation for the time evolution of a state ket. Schrödinger versus Heisenberg picture: state kets and observables in the Schrödinger and Heisenberg pictures. Schrödinger wave equation, conservation of probability. Main example: the Harmonic Oscillator. Operator Method , the Fock space and Coherent States.

Part II

1. **Relavistic Wave equations**
   The Lorentz Group. Klein-Gordon equation, The Dirac equation and its Lorentz covariance, Dirac and Weyl Spinors. Probability current. Bilinear covariants. Minimal Coupling to Electromagnetism. Nonrelativistic limit of the Dirac equation and gyromagnetic ratio of the electron. Solutions of the free Dirac equation: plane wave solutions, polarised electrons in relativistic theory. Projection operators for energy and spin.

2 **Discrete Symmetries in the Dirac theory and the zero mass limit**
   Charge conjugation and Hole Theory. Parity transformation and Time reversal transformations of Spinors. Chirality and Helicity. Neutrino's two components equation.