Syllabus of the course "Quantum Mechanics"
Instructor: Dr. Giulia Maria de Divitiis
Fall 2016 – Academic Year 2016-2017

1. Classical Mechanics: Lagrange, Hamilton and Hamilton–Jacobi equations. Quantum states, observables and time evolution. Schroedinger, Heisenberg and the interaction pictures. The Dyson series. Schwarz inequality and the generalized uncertainty principle.
   [S 1, 2.1, 2.3]

2. The coherent states of the harmonic oscillator. Heisenberg operators. Expansion in the energy eigenstate. Minimum uncertainty wave packets.
   [S 2.3]

3. The Density matrix and its properties. Pure and mixed states. Time evolution of the density operator: the von Neumann equation. Indicators of purity: ρ^2 and the Von Neumann entropy.
   Examples: The probability distribution at the thermal equilibrium, the case of spin 1/2 particles with partial polarization.
   [S 3.4]

4. The WKB approximation. Criterions of validity. Airy functions.The connection rules. Bohr-Sommerfeld energy quantization condition. Tunneling through a potential barrier.
   [S 2.4]

5. The propagator as a transition amplitude, general properties. Propagator as a Green's function. The Feynman's path integral representation. Commutators in the path integrals. Examples: the free particle, the harmonic oscillator. The Aharonov-Bohm effect. The Magnetic Monopoles and Charge Quantization.
   [S 2.5, 2.6]

6. The EPR paradox. The Bell's inequalities.
   [S 3.10]

7. The Lippmann-Schwinger integral equation.
   Basic concepts of scattering processes, definition of differential cross section, total cross section, scattering amplitude. The optical theorem.
   The Born series. The first Born approximation. Example: the Yukawa potential.
   [S 6.1, 6.2, 6.3]

8. The Klein–Gordon equation. The free solutions. The four current density. Not positive definite probability density and negative energies.
   The Dirac equation. The α, β matrices and the Dirac algebra. The conserved four current density. The free solutions labelled with the sign of energy and with the helicity. The covariant formulation of the Dirac equation and the γ matrices. The non relativistic limit and the Pauli Equation.
   [S 8.1, 8.2, BD chapter 1]

Reference textbooks:

S = J.J. Sakurai, J. Napolitano "Modern Quantum Mechanics", Addison-Wesley Publ. 2nd edition

BD = J. D. Bjorken and S. D. Drell"Relativistic Quantum Mechanics" McGraw-Hill