ADVANCED QUANTUM MECHANICS

[Juan Luis Mañes]

Relativistic quantum mechanics (8 hours)
The Klein-Gordon equation. The Dirac equation. Coupling to electromagnetic fields and non-relativistic limits. The limitations of RQM.

Path integrals (9 hours)
Propagators as path integrals. The free particle and the harmonic oscillator. Saddle-point method and semiclassical approximation. Relation to statistical mechanics. Infinite determinants.

The WKB method (5 hours)
Connection with path integrals. Bound states and Bohr-Sommerfeld quantization rules. Tunneling amplitudes.

Coherent states and classical fields (2 hours)
Harmonic oscillators and quantum fields. The classical limit. Green's functions and particle creation by a classical source.

Landau levels (3 hours)
Motion in a magnetic field. Momentum and velocity operators. Spectrum in a constant magnetic field. Landau levels and quantum Hall effect.

Berry's phase (6 hours)
The adiabatic principle. Geometric phase and Berry's vector potential. Examples.

Introduction to quantum open systems (9 hours)
Density matrices and entanglement. Generalized measurements. Superoperators and quantum jumps. The Lindblad equation.

Bibliography

R. Shankar, *Principles of Quantum Mechanics*, 2nd edition, Plenum Press 1994
L. I. Schiff, *Quantum Mechanics*, McGraw Hill 1968
K. Gottfried and T.-M. Yang, *Quantum Mechanics: Fundamentals*, 2nd edition, Springer 2003 C. Cohen-Tannoudji, *Quantum Mechanics*, 2nd edition, Wiley 1991
J. J. Sakurai, *Modern Quantum Mechanics*, Addison-Wesley 1994
M. Le Bellac, *Quantum Mechanics*, Cambridge U. Press 2012

Times for each subject are approximate. Blackboard lectures, no lecture notes or slides are provided. However, the relevant parts of the books in the bibliography can be downloaded from eGela.

Assessment by **written final exam**.