Postgraduate Diploma Course in Condensed Matter Physics 2017-18

Advanced Quantum Mecanics

{32 Lectures = 48 hours} G. Santoro, R. Fazio & A. Russomanno

1) Brief hystorical introduction. Wave-packets as a description of free non-relativistic particles. Schrödinger equation in real space, with applications to simple problems (one- dimensional square wells, including scattering problems). Overview of the formalism of QM (operators, matrices, eigenvalue problems, bra-and-kets). Different representations for the orbital wavefunction: momentum versus real space. The Stern-Gerlach experiment and the representation of spin states. The density matrix to describe mixed states.
2) Symmetries in QM. Rotations. Commutation relations of the angular momentum. General construction of angular momentum representations. Explicit construction of sperical harmonics. The spin-1/2 states seen as a representation of the angular momentum algebra. Pauli matrices. Composition of angular momenta (explicit construction of J=3/2 spin-orbital states), Clebsch-Gordon coefficients. Other symmetries: Double-well potential and Parity.
3) Central potentials and the hydrogen atom bound states.
4) Time-independent perturbation theory, starting from the two level system example, and formal development. Applications of the non-degenerate case. Degenerate perturbation theory. Application to the fine-structure of hydrogen.
5) Time-dependent perturbation theory, with examples. Fermi Golden rule.
6) Identical quantum particles: Fermions and bosons. Permutations, and the correct basis states. Pauli principle. Construction of the second quantization formalism.
Refs.: S. Gasiorowicz, "Quantum Physics", Wiley; J.J. Sakurai, “Modern Quantum Mechanics”, Addison-Wesley.