Course content for MT3250/MT4250, Quantum Theory II

Prerequisites:
MT3200

Aims:
To derive methods, such as the Rayleigh-Ritz variational principle and perturbation theory, in order to obtain approximate solutions of the Schrödinger equation.
To introduce spin and the Pauli exclusion principle and hence explain the mathematical basis of the Periodic table of elements.
To introduce the quantum theory of the interaction of electromagnetic radiation with matter using time dependent perturbation theory.
To show how scattering theory is used to probe interactions between particles and hence to show how the probability or cross section for a scattering event to occur can be derived from quantum theory.

Learning outcomes:
1. use various methods to obtain approximate eigenvalues and eigenfunctions of any given Schrödinger equation,
2. to understand the importance of spin in quantum theory,
3. to appreciate how the Periodic Table of elements follows from quantum theory,
4. to write down the Schrödinger equation for the interaction of electromagnetic radiation with the hydrogen atom and to work out photo-absorption cross sections for hydrogen,
5. to define the scattering cross section and to work it out for some simple systems.
6. MT4250: demonstrate a breadth of understanding appropriate for an M-level course.

Course content:
Variational principles in quantum mechanics: the Rayleigh-Ritz variational principle. Bounds on energy levels for quantum systems.
Perturbation theory: Rayleigh-Schrödinger time-independent perturbation theory. Perturbations of energy levels due to external electromagnetic fields.
The electron's spin: the eigenfunctions and eigenvalues of the spin operator. The Pauli exclusion principle. The periodic table of elements. Spin precession in an external magnetic field.
Radiative transitions: the absorption and emission of electromagnetic radiation by matter. Photo-absorption cross-sections for the hydrogen atom.
Scattering theory: definition of the scattering cross-section and the scattering amplitude. Decomposition of the scattering amplitude into partial waves. Phase shifts and the S-matrix. Integral representations of the scattering amplitude. The Born approximation. Potential scattering.