PY1P20 Quantum Mechanics

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Learning outcomes

At the end of this course students should be able to :

- Describe the principles of our current understanding of physics in terms of quantum mechanics, and contrast these principles with those of classical physics.
- Demonstrate understanding of the implications of these principles.
- Obtain solutions to simple problems in quantum mechanics, such as the infinite potential well, and discuss qualitatively more complex problems, such as the energy levels of atoms.

Syllabus

Lecture 1: Superposition, partial differential equations. Introduction to quantum physics.

Lecture 2: Light as a particle : photoelectric effect, Compton effect.

Lecture 3. Particles and waves. de Broglie relation, Davisson-Germer experiment. Structure of quantum mechanics contrasted with classical mechanics. Wave function of a free particle.

Lecture 4. Double-slit experiment for single particles, statistical meaning of the wave-function. Normalization of wavefunctions. Difference between adding probability amplitudes and adding probabilities.

Lecture 5. Where is a particle? Wavefunction collapse. Wave groups: phase and group velocity. Wavepackets move at the group velocity. Box-normalization of a 1D wave.

Lecture 6. The uncertainty principle. Incompatible observables (x and p) and relation to interference and diffraction (microscope thought experiment). Applications of the uncertainty principle: spreading of wavepackets and energy quantization.

Lecture 7: The Bohr model. What it gets right and what it gets wrong.

Lecture 8 : Thermal phenomena as the historical origins of quantum physics: specific heat of solids and the Black-body spectrum.

Lecture 9 : Expectation values. Schrodinger's equation. The steady-state Schrodinger equation.

Lecture 10 : Operators, eigenfunctions, and eigenvalues. Concept of a stationary state. Solutions to the steady-state Schrodinger equation I: particle in an infinite potential well, particle in a finite potential well.

Lecture 11: Solutions to the steady-state Schrodinger equation II: particle in a 2D box, harmonic oscillator.

Lecture 12: Reflection from a potential step. Finite potential barrier and tunneling.

Lecture 13: Angular momentum in quantum mechanics. Spin. Pauli exclusion principle

Lecture 14: The hydrogen atom. Atomic shell structure.

Lecture 15: Not everything is a stationary state: introduction to time-dependence. Single-photon interference revisited. Stern-Gerlach experiments. Fundamental postulates of quantum mechanics.