PHYSICS- 16: QUANTUM MECHANICS AND APPLICATIONS-II

Motivation for developing a linear vector space formulation to describe quantum phenomenon. Brief review of linear vector spaces with ket notation: Inner product, norm, Schwarz inequality, linear operators, eigenvalue and eigenvector, adjoint of a linear operator, Hermitian or self-adjoint operators and their properties, unitary operators, orthonormal basis – discrete and continuous. Connection with wavefunctions. Bra vectors. (6 Lectures)

Representation of quantum states with ket vectors and physical observables by Hermitian operators. Unitary time-evolution and Schrodinger equation in ket notation. Measurement of an observable and collapse of a state-vector; Born rule and probability. Expectation value of an observable. Canonical commutation relations - commutators of position and momentum, commutators for orbital and spin angular momentum. Compatible and incompatible observables: the uncertainty principle. Ehrenfrest's theorem and the classical limit. Correspondence with Schrodinger wave mechanics. Dynamics of two-level systems, such as electron spin in a uniform magnetic field. One dimensional Harmonic oscillator using ladder operators. Composite system consisting of two particles: direct product of kets. Identical particles: symmetric and antisymmetric states. Pauli's exclusion principle. (22 Lectures)

Application to atomic and molecular Physics: Addition of orbital and spin angular momenta, J= L+S. Commutators of Jx, Jy and Jz; ladder operators, eigenvalues and eigenstates of total angular momentum operators. Zeeman effect-normal and anomalous. Composite system consisting of two spin half particles - singlet and triplet states. Multi-electron atoms and the periodic table. Fine structure, spin orbit coupling, spectral notations for atomic states. L-S and J-J couplings. Variational method and its application in determining the ground state energy of Helium atom. The Hydrogen ion molecule. Rotational spectra: the rigid rotator and its energy eigenvalues. Vibrational spectra: the Morse potential and corresponding energy eigenvalues. The rotation-vibration spectra. Selection rules. Determination of internuclear distance. (20 Lectures)

Suggested study: (1) Matrix mechanics and the Heisenberg picture. (2) Coherent states. (3) Lattice vibrations and phonons (4) Neutron interference experiment in gravity. (5) Two state systems: atomic clocks; nuclear magnetic resonance; neutrino oscillations. (6) Quantum entanglement: Schrodinger's cat and EPR paradoxes; quantum computation - qubit as a superposition of |0> and |1> binary states, entangled qubits, parallel branches and parallel processing.

Reference Books:

- Modern Quantum Mechanic, J.J Sakurai, Revised Edition, 1994, Addision-Wesley
- Introduction to Quantum Mechanics, C. Cohen-Tannoudgi, B. Diu, F. Laloe, 1977, Wiley-VCH
- A Text book of Quantum Mechanics, P.M.Mathews & K.Venkatesan, 2nd Ed.,2010, McGraw Hill
- Quantum Mechanics, Brian H. Bransden and C. Charles Jean Joachain, 2000, Printice Hall
- Quantum Mechanics, Eugen Merzbacher, 3rd Ed., 1997, John Willey and Sons, Inc.
- The principles of quantum mechanics, P.A.M. Dirac`s, 2009, Springer

---

PHYSICS PRACTICAL-VII

(Students have to perform at least 5 simulations and 2 experiments from the section VIIB. Additional experiments may be included with approval of the committee of courses)

PHYSICS LAB.-VIIB

PSPICE simulation for electrical networks and electronic circuits

A. To verify the Thevenin and Norton Theorems.
B. Design and analyze the series and parallel LCR circuits
C. Design the low pass and high pass passive filters of given cutoff frequency
D. Design the inverting and non-inverting amplifier using an Op-Amp of given gain

E. Design and Verification of op-amp as integrator and differentiator
F. Design the first order active low pass and high pass filters of given cutoff frequency
G. Design the active band pass and band reject pass filters of given bandwidth
H. Design and analyze the Clippers and Clampers circuits using junction diode
I. Design a Wein`s Bridge oscillator of given frequency.
J. Design clocked SR and JK Flip-Flop`s using NAND Gates
K. Design 4-bit asynchronous counter using Flip-Flop ICs
L. Design the CE amplifier of a given gain and its frequency response.
M. Design an astable multivibrator using IC555 of given duty cycle.
N. Design a monostable multivibrator of given pulse width using IC555 Timer

List of experiments:

1. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
2. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
3. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of length of about 2m, understanding of importance of grounding using function generator of mV level and a digital oscilloscope.
4. To design and study the Sample and Hold Circuit.
5. Glow an LED via USB port of PC
6. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port

Reference Books:

- PC based instrumentation; Concepts and Practice, N. Mathivanan, 2007, Prentice-Hall of India.
- Introduction to PSPICE using ORCAD for circuits& Electronics, M.H.Rashid,2003, PHI Learning
- Electronic circuits:Handbook of design and applications, U. Tietze, Ch. Schenk, 2008, Springer
- Embedded Microcomputer systems:Real time interfacing, J.W.Valvano, 2012, Cengage Learning
- Basic Electronics:A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1990, Mc-Graw Hill
- Measurement, Instrumentation and Experiment Design in Physics & Engineering, M.Sayer and A. Mansingh, 2005, PHI Learning.
