Advance Astronomy and Astrophysics
Programe: MSc: 4th Sem
CODE: PAS 9201G
Credit: 4
Type: Elective Specialization

(Credits: Theory-04)

Course Objective: The prime aim of this course is to provide a very advanced level concepts and skills in astronomy and astrophysics especially in extragalactic astronomy at the post-graduation level.

Course Outcomes:

After completing the course satisfactorily, a student will be able:

- Understanding of the background Cosmology and structure formation
- Understanding of key radiative process in astronomy and astrophysics
- General understanding of the Accretion power in Astronomy
- Understanding of Active Galactic Nuclei and their role to study high-z Universe

Course Objective:

The prime aim of this course is to provide a pedagogical introduction to advanced astronomy and astrophysics for the PG course as a specialization course in extragalactic astronomy.

UNIT-I: Background Cosmology and structure formation (10 lectures)

Friedmann models (geometrical and physical aspects) - Comoving coordinates,Scale factor, Hubble's Law,FRW metric, FRW universe kinematics, Distances in cosmology(luminosity distance,angular diameter distance), FRW universe dynamics. Big bang nucleosynthesis, Thermal history of the universe from T = 1 GeV to T = 900 K - Linear growth of perturbations comparison with observations of Lyman alpha-Forest and Cosmic microwave background

Unit-II: Radiative process in astronomy (10 lectures)

Macroscopic description of radiation field - Moments of radiative transfer equations and simple approximate solution. Radiative processes in astrophysical systems : Bremsstrahlung, synchrotron radiation, Compton and inverse Compton processes -

Unit-III: Accretion power in Astronomy (10 lectures)

Fluids in Astrophysics, Macroscopic nature of fluids-Mean density, pressure, temperature, velocity Ideal fluid dynamics - Conservation of Mass, Momentum-Euler equation (both 1D and 3D treatments), Equation of state. Bernoulli Principle for steady flows and applications: justification for incompressible fluid flows, Pitot tube.

Gas dynamics equations, adiabatic and isothermal flows, sound waves, spherical symmetric accretion.

Unit-IV: Active Galactic Nuclei (10 lectures)

Active Galactic Nuclei unification scheme, Accretion disc radial structure, Emitted spectrum, Structure of standard alpha-disc models and its confrontation with observations Multi-wavelength study of AGN. Reverberation mapping of AGN.

Prescribed Text Book:

1. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
2. Accretion power in Astrophysics, Juhan Frank, Andrew King an Derek Raine
3. Physics Volume I : Astrophysical Processes Padmanabhan, T. Published by Cambridge University Press
4. Theoretical Astrophysics Volume III : Galaxies and Cosmology Padmanabhan, T. Published by Cambridge University Press…
5. Structure formation of the Universe, by T. Padmanabhan Published by Cambridge University Press…
6. Introduction to cosmology, by Jayant V. Narlikar Published by Cambridge University Press.

Material Science-II

Course Code:PAS9201P
Credits: 4

Course Objectives:

The purpose of the course is to provide a comprehensive introduction and application of the quantum materials and develop pre-requisite for the next course 'Advanced Quantum Materials Science -2(MAT-2)'. Starting from Fundamentals of different kinds of materials.

Course Outcomes:

On completion of the course the student should have the following learning outcomes defined in terms of knowledge, skills and general competence: The student has gained knowledge about

CO1: *basic quantum mechanics*
CO2: *Tight Binding Hamiltonian, Basic Statistical Mechanics & Mathematical Physics*
CO3: *Self energies of left and right contact*
CO4: *approximate methods for solving the Schrödinger equation with finite difference method*
CO5: *Anderson Localization, Green Functions & Self consistency of different methods.*

Course Contents

Unit 1 Atomistic View **(10 hours)**

- An atomistic view of electrical resistance,
- Energy Level diagram,
- Quantum of conductance,
- Potential Profile,
- Coulomb blockade,
- Towards Ohm's law

Unit 2 Schrodinger equation **(10 hours)**

- Schrodinger equation,
- Hydrogen atom,
- Subbands,
- Quantum Wells, wires,
- Density of states,
- Minimum resistance of a wire,
- Velocity of a subband electron

Unit 3: Self consistent Method (10 hours)

- Self consistent field procedure,
- Relation to the multi electron picture,
- Bondings and multi electron picture,
- Basis function as a computational tool and conceptual tool,
- Equilibrium Density matrix
- LDOS,
- Spectral function.

Unit 4: Level Broadening (10 hours)

- Level Broadening,
- Open systems,
- Local density of states,
- Density matrix,
- Inflow and out flow,
- Quantum transport equations,
- Where is heat and voltage drop

Unit 5: Scattering (10 hours)

- Coherent
- Non coherent transport ,
- Why does an atom emit light ?

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Unit 6: Electron Transport Theory (6 hours)

- Kubo Formula,
- Drude conductivity,
- Self energy and the Diagramatic derivation,
- Electron Diffusion

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Prescribed Textbooks:

1. Solid state Physics by Charles Kittel.
2. Quantum Transport :atom to transistor by Supriyo Datta(2005).
3. Introduction to Mesoscopic Physics by Yoseph Imry

Qunatum Computing

Credits: 02 **Paper Code- PAS9207**

Section-A

History & overview: Classical vs quantum computing. Linear Algebra for quantum computing: Vector space, linear operators, inner product, eigenvectors and eigenvalues, singular value decomposition, Trace of an operator, Projection Operator. Quantum Mechanics for quantum computing: Quantum state, superposition, time evolution, unitary transformations, quantum measurements

(15 Lectures)

Section-B

Quantum bit, Bloch sphere presentation of a qubit, two qubits, Quantum gates:- Identity gate, Pauli gates, Controlled gates, Phase shift gates, Hadamard gate, Swap gate,Toffoli (CCNOT) gate and Universal gates.

References:

1. Quantum Computation and Quantum Information by Michael Nielsen and Isaac L. Chang, Cambridge University Press.
2. Handbook of Quantum Information
3. Quantum Information Science and Technology Roadmaps