

# Advance Solar Physics Course

## I. Solar Internal Structure and Dynamics and Solar Oscillations (Helioseismology):

- Solar Interior Structure and Dynamics: (i) Composition and structure of the Sun (ii) Energy transport from the solar interior to the solar atmosphere (iii) Large- and small-scale velocity fields (iv) Solar rotation and internal dynamics (v) Solar magnetism
- Solar Oscillations: (i) Theory of solar oscillations (ii) Properties of solar oscillations (iii) Observations of solar oscillations and observational requirements
- Global Helioseismology: (i) Direct and Inverse Theory (ii) Ground- and space-borne observations (iii) Helioseismic inferences of solar structures (iv) Helioseismic inferences of solar rotation (v) Helioseismic inferences of solar magnetism
- Local or Active Region Helioseismology: (i) Observational requirements (ii) Methods of local helioseismology (iii) Inferences
- Data Reduction & Analysis (Helioseismology): (i) Discussion on the types and format of helioseismic data available from the instruments (ii) Submission of data requisition to the various data centers and acquisition (iii) Data handling using IDL (iv) Interpretation of reduced data:  $p$ -modes, granulations/supergranulations, L-Nu diagram, Ring diagram, Far-side imaging using the method of Acoustic Holography

## II. Solar Magnetohydrodynamics (MHD):

- Definition of plasma, quasineutrality and collective property, Debye Shielding, gyro-frequency, plasma frequency and oscillation
- Liouville's theorem, Vlasov-Maxwell equation and its various moments
- Two-fluid and single-fluid magnetohydrodynamics, Two-fluid steady states, canonical momentum and vorticity, double-curl Beltrami field. Single-fluid equilibrium, Grad-Shafranov equation and its analytical solutions for linear-force-free and potential fields. Chandrasekhar-Kendall representation of linear-force-free fields, its significance in modeling the solar coronal magnetic fields and magnetic flux ropes
- Magnetic reconnection, Sweet-Parker Model, Introduction to Petscheck model, X-type and Y-type neutral lines
- Relaxation of magnetized plasmas, Turbulence, forward and inverse cascade, Magnetic helicity, Taylor relaxation and Woltjer relaxation, selective decay principle, magnetic helicity in isolated and open systems
- Shear and compressional Alfvén waves, magneto-acoustic modes, Lower and upper hybrid oscillations
- Parker turbulent dynamo, mean-field magnetohydrodynamics and the dynamo-wave solution, Flux transport dynamo

### **III. The Active Sun and the Space Weather:**

- Sunspots
- Solar active regions
- Coronal loops
- Solar flares: standard flare model, radiative processes, flare spectroscopy, pre-flare conditions, triggering mechanism, HXR and MW bursts
- Solar prominences
- Coronal mass ejection (CME): early evolution, eruption, space weather consequences

### **IV. Solar Instrumentation:**

- Observables and general difficulties
- Optical elements for solar observations
- Solar velocity and magnetic field measurement techniques
- Types of solar telescopes
- Typical examples of ground- and space-based instruments