PHY 651: An Introduction to Astrophysical Fluids

COURSE INSTRUCTOR: SUPRATIK BANERJEE, DEPARTMENT OF PHYSICS, IIT KANPUR

(ELECTIVE COURSE OF 40 LECTURE HOURS DESIGNED FOR PH. D., M. SC. AND ADVANCED UG STUDENTS)

ACADEMIC YEAR: 2018-2019; FIRST SEMESTER

INTRODUCTION

The physics of astrophysical fluids is the subject of active research during past seventy years. Starting from the solar wind, magnetospheric plasmas, the scope of astrophysical fluids includes interstellar clouds. A thorough understanding of the astrophysical fluid dydnamics is essential to understand fascinating phenomena like the formation of solar flares, the properties of the solar wind, reconnection and even the physics of star formation.

This course is structured to give the students a systematic and thorough understanding of various astrophysical events along with a research oriented outlook.

PREREQUISITE

- ☞ Elements of vector algebra and vector calculus, basics of partial differential equations.
- ☞ Basic notions of fluid dynamics and electrodynamics (Maxwell's equations, Ohm's law etc.)

COURSE CONTENT

- Qualitative introduction to astrophysical fluids.
- Derivation of hydrodynamic fluid equations (Euler equations, Navier-Stokes equations) from kinetic theory of gases.
- Spherically symmetric flows, flows with rotation (stellar models, meridional circulation etc.).
- Stratified media (stellar models, planetary atmosphere etc.).
- Different types of stellar oscillations and waves.
- Different instabilities: Jeans instability, thermal instability, Kelvin-Helmholtz instability, Rayleigh-Taylor instability.
- Turbulence in hydrodynamic fluids: phenomenology, structure functions, properties of turbulence in cold molecular clouds.
- Modelling of space and astrophysical fluids as plasmas: introduction to plasmas, derivation of the equations of Magnetohydrodynamics (MHD), invariants and different properties of MHD, waves, concept of dynamo.
- Instabilities in magnetofluids, their important in space and astrophysics.
- Turbulence in an MHD fluid: basic introduction and its importance in modern research of space science and Astrophysics.

COURSE LOAD AND GRADING POLICY

- ✙ 3 lecture hours per week (2 seesions of 1.5 lecture hours each).
- ✙ Final grade: 2 Quizzes (20%) + Mini project (30%) + End-semester examination (50%); Mid-semester examination will be replaced by mini project based on course thematic.

REFERENCE

[1] Arnab Rai Chaudhuri, The Physics of Fluids and Plasmas: An Introduction for Astrophysicists, Cambridge University Press.

[2] J. E. Pringle and A. King, Astrophysical Flows, Cambridge University Press.

[3] E. R. Priest, Solar Magnetohydrodynamics (Geophysics and Astrophysics Monographs), Springer.

[4] J. A. Bittencourt, Fundamentals of Plasma Physics, Springer.

[5] S. Chandrasekhar, Hydrodynamic and Hydromagnetic Stability, Dover Books on Physics.