Seminar

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Institute for Plasma Research

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Title: Particle transport in 2D Navier-Stokes fluids

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Date: 22nd September 2025 (Monday)

Time: 03:00 PM

Venue: Board Room, IPR

Abstract

Fluid turbulence is a ubiquitous phenomenon spanning all natural scales, from cosmological structures to quantum systems. Turbulence governs the formation of galaxies, stars, and planetary systems, drives magnetic-field generation and particle acceleration in astrophysics, shapes atmospheric and oceanic circulation whose understanding aids weather prediction and environmental management in geophysics, and limits confinement and performance in controlled plasma devices such as Tokamaks and Stellarators. Thus, investigating turbulence and the dynamical behavior of fluids and plasmas is essential for advancing our understanding and to better our capacity to manipulate for technological gains.

Understanding fluid dynamics requires investigation from both Eulerian and Lagrangian perspectives, where the Eulerian framework describes the field quantities of the fluid from a laboratory's rest frame, and the Lagrangian approach tracks the motion of fluid elements via test particles to quantify transport and uncover underlying chaotic structures. To this end, we employ an in-house developed, GPU-based 2D fluid solver, GHD2D [1], for studying neutral fluids, and has recently upgraded it to include a particle solver into this framework [2]. This upgraded version has been tested and benchmarked. Using this integrated code, we investigate the transport properties of Navier–Stokes 2D hydrodynamic turbulent systems—initiated by Kelvin–Helmholtz instability and which is allowed to decay freely—to study the long-term behavior of test particles. The nature of turbulent transport is analyzed by varying the initial vorticity packing fraction [2], the initial vorticity circulation, and the effects of compressibility. Several preliminary results from these studies will be presented along with the planned future work for application to higher-dimensional turbulent systems and electrically conducting fluids.

[1] S. Biswas, Turbulent dynamo action in a 3-dimensional magnetohydrodynamic plasma: A PhD Thesis (Homi Bhabha National Institute and Institute for Plasma Research, India, 2024).
[2] Maiti, S., Biswas, S., & Ganesh, R. (2025). Vorticity Packing Effects on Turbulent Transport in Decaying 2D Incompressible Navier-Stokes Fluids. arXiv:2509.09487, (September, 2025).