**The Enigma of Turbulence in Polymeric Flows**

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## Brief Biographical Sketch

Rahul Kumar Singh specialises in various aspects of complex, multiphase, turbulent flows. He has worked on both high and low Reynolds number flows of polymeric fluids, the transport properties of elastic, anisotropic particles -- which model contaminants -- in turbulent flows and low Reynolds number active turbulence. Rahul completed his BTech from IIT (ISM) Dhanbad in 2013 and served in the industry in the following two years. Subsequently, he obtained his MSc and PhD in Physics from International Centre for Theoretical Sciences (ICTS-TIFR), Bengaluru in June 2022. After his PhD, he joined the Complex Fluids and Flows Unit at the Okinawa Institute of Science and Technology (OIST) as a postdoctoral researcher in July 2022.

## Abstract

Polymeric fluid flows exhibit a wide range of complex dynamical behaviours that challenge classical ideas in fluid mechanics. Well-known examples include turbulent drag reduction, as well as the more recently identified elastic turbulence (ET) at low Reynolds numbers (Re) and polymeric turbulence (PT) at high Re. In this two-part seminar, we discuss new physical and statistical insights in both these regimes which challenge the conventional Kolmogorov wisdom of turbulence.

In the first part, we focus on polymeric turbulence at large Re. We demonstrate that PT displays a universal scaling behaviour that differs fundamentally from the classical Kolmogorov (K41) picture of Newtonian turbulence. Building on a framework that reconciles PT statistics with K41 phenomenology, we identify the emergence of a second invariant measure that governs the observed self-similarity. The physical relevance of this invariant is confirmed through velocity and vorticity statistics, providing new insight into how polymer elasticity modifies turbulent cascades.

In the second part, we turn to elastic turbulence, a state of strongly chaotic flow that arises at very small Re due to elastic stresses introduced by polymer additives. We show that the apparent universality and self-similarity of ET can be traced to a previously hidden, subdominant rough scaling of velocity fluctuations, revealed through second-difference structure functions. These statistics exhibit strong intermittency and pronounced deviations from Gaussian behaviour, highlighting the multiscale nature of elastic stress-flow coupling.