TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Dipartimento di Fisica

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Seminar

Tuesday, 3 October 2023 - h. 14:30

Fisica della Materia room (Department of Physics)

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"A journey into the turbulent velocity gradient dynamics"

Abstract

The small scales of turbulent flows deserve attention from both a theoretical and practical viewpoint. For example, they encompass several turbulent hallmarks, such as cascades and extreme intermittency, and play a pivotal role in shaping the clustering and formation of caustics in the dynamics of particles advected by turbulent flows. The question arises: Can we model those small scales without resorting to the entire multi-point velocity field statistics.
One avenue to comprehensively describe small-scale turbulence lies in the velocity gradients. In this talk, we will explore the modelling of their fascinating dynamics from low-Reynolds numbers regimes to fully developed turbulence. We will get analytic insight into the onset of turbulence-specific features, such as skewness, intermittency and preferential alignments at low Reynolds numbers. We will witness a transition to a typical turbulent configuration of the velocity gradients at higher Reynolds numbers and subsequently move on to data-driven modelling of fully developed small-scale turbulence. The proposed modelling approach involves approximating the single-time probability density function (PDF) of the velocity gradients through analytic parameterization or machine learning methods. Building on this, we will formulate classes of dynamical systems designed to replicate the parameterized or learned PDF, and then we will refine the multi-time statistics using some leftover gauge terms for the single-time statistics.
As a related application, I will show preliminary results from the numerical simulation of sub-Kolmogorov iron particle combustion in turbulence. In this context, the interplay between the igniting particles and the extreme temperature and velocity gradients gives rise to a host of intriguing and yet unexplored phenomena.

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