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Whorls in transitional pipe flows

Professor Pinaki Chakraborty

Okinawa Institute of Science and Technology, Japan

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Abstract:

As everyone knows who has opened a kitchen faucet, pipe flow is laminar at low flow velocities and turbulent at high flow velocities. At intermediate velocities, the flow assumes a peculiar state, as was first investigated by Osborne Reynolds in 1883. The flow is in a transitional state, wherein plugs of laminar flow alternate along the pipe with “flashes” (Reynolds’ term) of fluctuating flow with whorls. Little is known about the statistical structure of these whorls. We show that, surprisingly, the whorls in flashes partake in the Kolmogorovian energy cascade, even though the energy cascade is generally thought to be restricted to idealized turbulent flows at very large Reynolds number, Re (a dimensionless measure of flow velocity). Our finding suggests that new insights into the transition to turbulence may be gained by approaching the transition from above, from higher to lower Re , complementing the usual approach from below.

This work is in collaboration with Rory Cerbus, Chien-chia Liu, and Gustavo Gioia.

