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Transitional Flows in Imperfect Millimeter-Scale Channels

CHARLES LISSANDRELLO, LE LI, KAMIL L. EKINCI, VICTOR YAKHOT, Department of Mechanical Engineering, Boston University — The majority of workers studying transition to turbulence in pipes have been interested in the flow response to perturbations in otherwise perfect pipes. Conversely, the fuzzy problem involving inlet disturbances, pipe imperfections, and pipe roughness has not attracted as much attention. Here, we investigate both experimentally and theoretically the transition to turbulence in imperfect millimeter-scale channels. For probing the flows, we use microcantilever sensors embedded in the channel walls. We perform experiments in two nominally identical channels. We quantify growing perturbations near the channel wall by their spectra and statistical properties, including probability densities and low- and high-order moments. The different sets of imperfections in the two channels result in two random flows in which the high-order moments of the near-wall fluctuations differ by orders of magnitude. Surprisingly, however, the lowest-order statistics in both cases appear to be qualitatively similar and can be described by a proposed noisy Landau equation for a slow mode. The noise, regardless of its origin, regularizes the Landau singularity of the relaxation time and makes transitions driven by different noise sources appear similar.

Charles Lissandrello
Department of Mechanical Engineering, Boston University

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