TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Mercoledì 9/11 ore 15:30 Aula Convegni, Facoltà di Ingegneria
Via del Politecnico 1, 00133, Roma

Nascent fractal scaling during transition to turbulence: discovery using machine learning, virtual sensors, and a public database system

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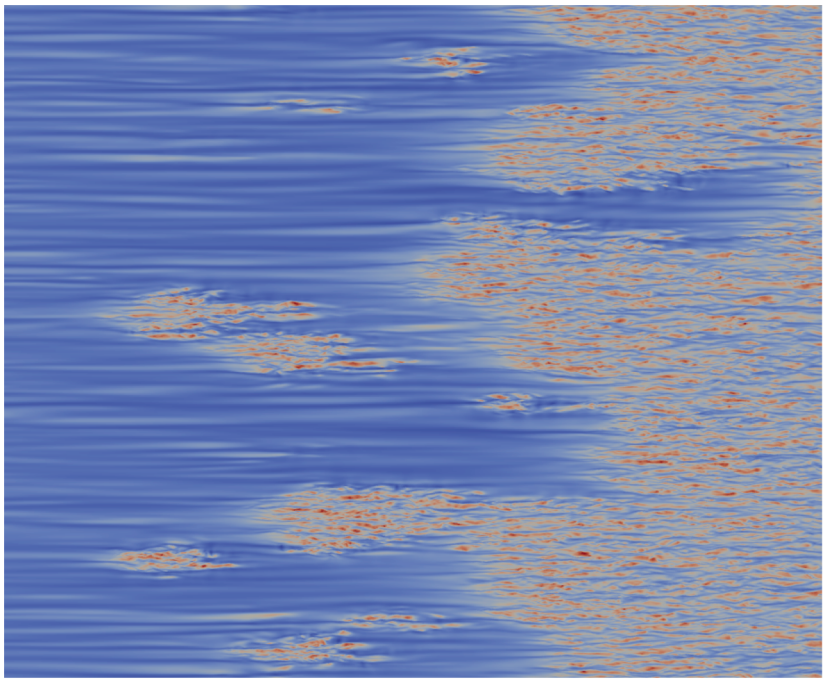
When a boundary layer developing on a smooth surface transitions from a laminar to a turbulent state, the process is often accompanied by the appearance of spatially localized patches (spots) of turbulence that grow and merge downstream to become the fully turbulent boundary layer. A long-standing question has been whether these incipient spots already contain properties of high-Reynolds-number, developed turbulence. Here, we pose this question for geometric scaling properties of the interface separating the turbulence within the spots from the outer flow. For high-Reynolds-number turbulence, such interfaces are known to display fractal scaling laws with a dimension near D = 7/3, where the 1/3 excess exponent above 2 (smooth surfaces) follows from Kolmogorov scaling of velocity fluctuation's spatial increments. The data used in this study to examine geometric scaling properties are from a direct numerical simulation (DNS). The data are archived in an open database system (the Johns Hopkins Turbulence Database), where data access is facilitated by a user-friendly "virtual sensors" approach. At present JHTDB contains over 1/2 Petabyte of DNS data from various turbulent flow simulations, and it has been used in over 250 peer-reviewed journal publications on turbulence from authors world-wide. Based on these data, we show that the spot boundaries (interfaces) can be determined by using an unsupervised machine-learning method that identifies such interfaces without the need to choose arbitrary thresholds. Scaling properties of the interface are studied and links to fractal properties of turbulent non-turbulent interfaces in high Reynolds number flows are established. This work has been performed with Drs. Zhao Wu and Tamer Zaki, while the database (supported by the NSF) has resulted from a long-term collaboration with the JHTDB team.



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