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Volume-Area and Area-Perimeter Dimensions of Turbulent-Spots Interfaces in Transitional Boundary-Layer Flow[1] ZHAO WU, TAMER ZAKI, CHARLES MENEVEAU, Johns Hopkins University — The nature of turbulent spots in transitional boundary layers, and whether their internal structure shares characteristics of equilibrium turbulence, remain open questions of considerable interest. Here we study scaling properties of the interface separating the spots from the outside flow. For high-Reynolds-number turbulence, such interfaces are known to display fractal scaling with a fractal dimension near D=2+1/3, where the 1/3 can be related to the Kolmogorov scaling of velocity fluctuations (e.g. de Silva et al. PRL 2013). We measure the volume-area fractal scaling of the naturally triggered turbulent spots. The data are from the DNS of a transitional boundary layer available at the JHTDB (http://turbulence.pha.jhu.edu). The spot boundaries (interfaces) are determined without arbitrary threshold selection using an unsupervised machine learning method, namely the self-organizing map (Zhao et al. PRF 2019). Results from the volume-area fractal dimension confirm D=7/3, i.e. trends consistent with fully developed turbulence. Applying an alternative area-perimeter analysis on planar cuts at various heights shows D decreasing then increasing. It is argued that these trends could be associated to changes in the thickness of the interface at different heights from the wall.

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