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Some implications of self-similarity in canonical wall turbulence

Beverley McKeon

Theodore von Karman Professor of Aeronautics, California Institute of Technology Pasadena, CA

ABSTRACT:

The financial and environmental cost of turbulence is staggering: manage to quell turbulence in the thin boundary layers on the surface of a commercial airliner and you could almost halve the total aerodynamic drag, dramatically cutting fuel burn, emissions and cost of operation. Yet systems-level tools to model scale interactions or control turbulence remain relatively under-developed. The resolvent analysis for turbulent flow proposed by McKeon & Sharma (J. Fluid Mech, 2010) provides a simple, but rigorous, approach by which to deconstruct the full turbulence field into a linear combination of (interacting) modes, exploit sparsity and low-rank behavior in the linear Navier-Stokes operator, and investigate flow dynamics. Recent developments are exploited here to investigate a low-order representation of self-similar behavior, to identify commonalities and differences between this approach and observations in the literature, and to draw some conclusions concerning the requirements for self-similarity and self-sustaining processes in wall turbulence.

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BIOGRAPHY:

Beverley McKeon is Theodore von Karman Professor of Aeronautics at the Graduate Aerospace Laboratories at Caltech (GALCIT). Her research interests include interdisciplinary approaches to manipulation of boundary layer flows using morphing surfaces, fundamental investigations of wall turbulence at high Reynolds number, the development of resolvent analysis for modeling turbulent flows, and assimilation of experimental data for efficient low-order flow modeling. She was the recipient of a Vannevar Bush Faculty Fellowship from the DoD in 2017, the Presidential Early Career Award (PECASE) in 2009 and an NSF CAREER Award in 2008, and is an APS Fellow and AIAA Associate Fellow. She is the past editor-in-chief of Experimental Thermal and Fluid Science and currently serves as an associate editor of Physical Review Fluids, and on the editorial boards of the AIAA J., Annual Review of Fluid Mechanics and Experiments in Fluids. She is the APS representative and Vice Chair Elect of the US National Committee on Theoretical and Applied Mechanics.