Synthesizing Wall Turbulence

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The linear dynamics of the Navier-Stokes equations have been studied in detail in recent years. In this talk, we identify observable features of wall turbulence that have an efficient representation as a linear combination of modes derived from the linear Navier-Stokes operator. Explicitly, we focus on a basis derived from the resolvent operator that serves as the transfer function between turbulent velocity and pressure fluctuations and the quadratic nonlinearity in the velocity (McKeon & Sharma, 2010) and give a brief summary of connections to other related work.

It will be shown that the mathematical structure of the resolvent gives rise to compact descriptions of a range of coherent structures in high Reynolds number wall turbulence, including the near-wall cycle of streaks and quasi-streamwise vortices, packets of hairpin vortices, very-large-scale and large-scale motions, as well as exhibiting different regimes of self-similarity, as reviewed in McKeon (2017). After exploiting the power of the linear representation of individual structure types, we isolate individual nonlinear interactions under the constraints of triadic consistency to study the coupling between scales. Finally, we use the resolvent basis to synthesize more complex fluctuating fields and identify conditions for self-sustaining turbulence. Implications for modeling, simulation and control will be discussed.

REFERENCES

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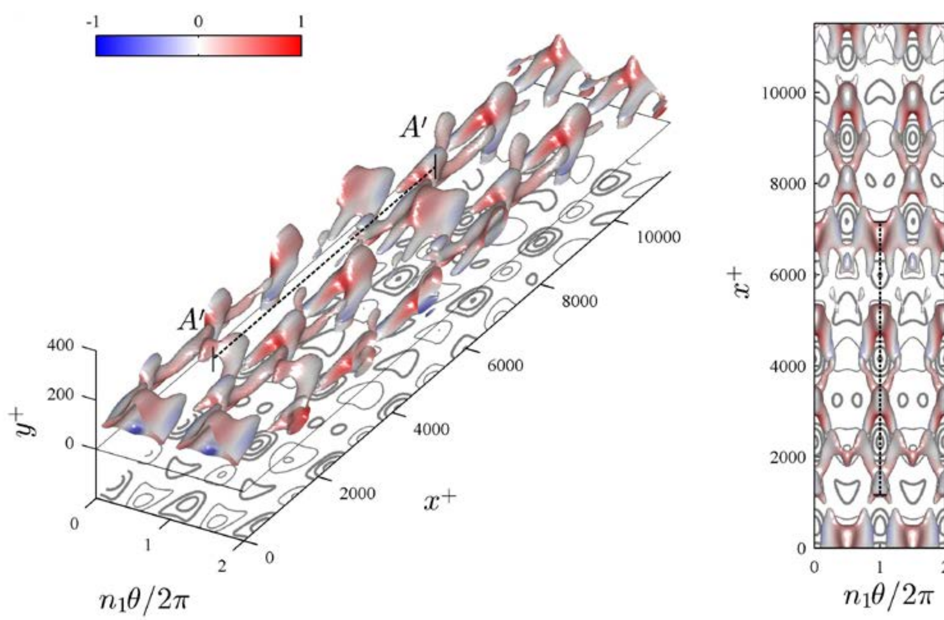

An assembly of three basis functions (first singular functions of the resolvent) gives rise to coherent structure resembling hairpin packets identified using the swirl criterion and an associated wall pressure signature. From Luhar *et al.* (2014).