Experiments, simulation and modeling in wall turbulence:
Towards "designer turbulence"

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In this talk, we describe complementary experimental studies, simulations and modeling efforts to uncover low order and sparse representations of complex turbulent flows and to enhance understanding of the essential underlying dynamics. Systems-level tools to model scale interactions or control turbulence remained under-developed until the recent past. Resolvent analysis for turbulent flow provides a simple, but rigorous, approach by which to deconstruct the full turbulence field into a linear combination of modes which interact through the nonlinear term. In this talk, resolvent analysis is used to explore the influence of passive and active control techniques on turbulence structure. Model results obtained using desktop computing power are compared with direct numerical simulation and complex experiments, highlighting the utility of resolvent analysis as a design tool for schemes to control wall turbulence, and the dramatic reduction in complexity associated with sparsity and low-rank behavior in the resolvent.