Abstract Submitted
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Model-based scaling and prediction of streamwise energy spectrum at high Reynolds numbers[1] RASHAD MOAREF, Graduate Aerospace Laboratories, Caltech, USA, ATI S. SHARMA, Automatic Control & Systems Engineering, University of Sheffield, UK, JOEL A. TROPP, Computing & Mathematical Sciences, Caltech, USA, BEVERLEY J. MCKEON, Graduate Aerospace Laboratories, Caltech, USA — To better understand the behavior of wall-bounded turbulent flows at high Reynolds numbers, we study the Reynolds number scaling of the low-rank approximation to turbulent channel flows. Following McKeon and Sharma (J. Fluid Mech. 2010), the velocity is decomposed into propagating waves (with single streamwise and spanwise wavelengths and wave speed) whose wall-normal shapes are determined from the principal singular function of the corresponding resolvent operator. We identify three regions of wave parameters that induce intrinsic Reynolds number scales on the low-rank model, reveal the universal shape of the streamwise energy spectrum for the model subject to broadband forcing, and show that this model captures the dominant near-wall turbulent structures. The model-based streamwise spectrum is then shaped by optimal weight functions to match direct numerical simulations throughout the channel at low Reynolds numbers. Representation of the resulting weight functions using similarity laws facilities predictions of the streamwise energy spectra at high Reynolds numbers ($R_\tau \approx 10^3 - 10^6$) which are shown to agree closely with experiments.

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Rashad Moarref
GALCIT, Caltech, USA

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