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A Singular Value Analysis of Boundary Layer Control

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Several approaches for boundary-layer control are analyzed from a linear system point of view. The singular value decomposition (SVD) is applied to the linearized Navier–Stokes system in the presence of control. The performance of control is examined in terms of the largest singular values, which represent the maximum disturbance energy growth ratio attainable in the linear system. The maximum growth ratio is shown to be less in controlled systems than in the uncontrolled system only when control parameters are within a certain range of values. The SVD analysis of various controls shows a similarity between the trend observed in the SVD analysis (linear) and that observed in direct numerical simulations (nonlinear), thus reaffirming the importance of linear mechanisms in the near-wall dynamics of turbulent boundary layers. The present study illustrates that the SVD analysis can be used as a guideline for designing controllers for drag reduction in turbulent boundary layers.

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