UCLA Samueli School of Engineering

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Bypass transition in high-speed separated boundary layers

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ABSTRACT: We utilize resolvent and weakly nonlinear analyses in combination with direct numerical simulations (DNS) to identify mechanisms for bypass transition in a Mach 5 flow over an adiabatic slender double-wedge. Even though the laminar separated flow is globally stable, resolvent analysis demonstrates significant amplification of unsteady external disturbances. These disturbances are introduced upstream of the separation zone and they lead to the appearance of oblique waves further downstream. We demonstrate that large amplification of oblique waves arises from interactions of the fluctuation shear stress with streamline curvature of the laminar base flow in the separated shear layer. This is in contrast to the attached boundary layers, where no such mechanism exists. We also use a weakly nonlinear analysis to show that the resolvent operator associated with linearization around the laminar base flow governs the evolution of steady reattachment streaks that arise from quadratic interactions of unsteady oblique waves. These quadratic interactions generate vortical excitations in the reattaching shear layer which lead to the formation of streaks in the recirculation zone and their subsequent amplification, breakdown, and transition to turbulence downstream. Our analysis of the energy budget shows that deceleration of the base flow near reattachment is primarily responsible for amplification of steady streaks. Finally, we employ DNS to examine latter stages of transition and demonstrate the predictive power of input-output framework in uncovering triggering mechanisms for oblique transition in separated high-speed boundary layer flows.
Joint work with: Anubhav Dwivedi and G. S. Sidharth

BIO: Mihailo Jovanovic is a professor in the Ming Hsieh Department of Electrical and Computer Engineering and the founding director of the Center for Systems and Control at the University of Southern California. He was a faculty member in the Department of Electrical and Computer Engineering at the University of Minnesota, Minneapolis, from 2004 until 2017, and has held visiting positions with Stanford University, the Institute for Mathematics and its Applications, and the Simons Institute for the Theory of Computing. His current research focuses on modeling, dynamics, and control of fluid flows; large-scale and distributed optimization; design of controller architectures; and fundamental limitations in the control of networks of dynamical systems. Prof. Jovanovic received a CAREER Award from the National Science Foundation in 2007, the George S. Axelby Outstanding Paper Award from the IEEE Control Systems Society in 2013, and the Distinguished Alumnus Award from the University of California at Santa Barbara in 2014. He is a Fellow of the American Physical Society (APS) and the Institute of Electrical and Electronics Engineers (IEEE)

Pizza will be served

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