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On the Control of a Canonical Separated Flow

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Abstract: Flow separation is generally an undesirable phenomenon that produces adverse aerodynamic effects. Control of flow separation is a complex problem and thus a popular area of research. A common obstacle is the lack of understanding of the complex fluid mechanics in cases of flow separation, evident by the substantial amount of flow control achieved through trial-and error methods. The purpose of this work is to better understand the nature of separation for improved active control methods, which includes closed-loop control via reduced order methods. Control of a canonical separation problem, with the key features of separated flow, is achieved at a chord Reynolds number of 10^5. Separation is created on a flat-plate model, devoid of curvature that would otherwise include effects particular to the type of aerodynamic body. The characteristics of the imposed separation are evaluated with the intent of having a nominally two-dimensional separated region, with the same essential flow characteristics of a traditional stall. Results provide a reduced-order estimation technique that is used to identify global, dynamic modes through measurements. Reattachment of the baseline separation is then achieved in open-loop control via zero-net mass-flux (ZNMF) actuation. Efficient reattachment is achieved by targeting the identified characteristic flow frequencies, enabling reattachment of the separated flow with less than a quarter of the control effort compared to open-loop high-frequency sinusoidal forcing. The baseline and control results are then used to identify a reduced-order model suitable for closed-loop control, with the resulting benefits of set-point tracking and full boundary layer reattachment with minimum control effort.

Bio: Louis N. Cattafesta III is currently a University Eminent Scholar and Professor in the Department of Mechanical Engineering in the FAMU/FSU College of Engineering. He is also the Director of the Florida Center for Advanced Aero Propulsion (FCAAP). He received a BSME in 1986 from Penn State University, a MS degree in Aeronautics from MIT in 1988 and a Ph.D. degree in ME in 1992 from Penn State. He then joined High Technology Corporation as a Research Scientist at NASA Langley where he focused on supersonic laminar flow control and pressure- and temperature-sensitive paint measurement techniques, active control of flow-induced cavity oscillations and aeroacoustics. He joined the University of Florida as faculty in 1999 and was promoted to an Associate and Full Professor in 2003 and 2008, respectively, before joining Florida State University in 2012. His research is supported by NASA, AFOSR, ONR, NSF, Boeing, Lockheed-Martin, GE amongst others. Dr. Cattafesta is the author or co-author of 7 US Patents and nearly 80 archival journal publications. He is an Associate Fellow of AIAA and a Fellow of APS and ASME. He is currently an Associate Editor for *Experiments in Fluids*. Prior to this he was an Associate Editor for *AIAA Journal*.

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