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Turbulent separation delay via tuned wall-impedance on a NACA 4412 airfoil in pre-stalled conditions. JULIEN BODART, GRIGORY SHELEKHOV, ISAE-Supaero, DAEP, CARLO SCALO, University of Purdue, School of Engineering, LAURENT JOLY, ISAE-Supaero, DAEP — We have performed large-eddy simulations of turbulent separation control via imposed wall-impedance on a NACA-4412 airfoil in near-stalled conditions (Mach, $M_\infty = 0.3$, and chord-Reynolds numbers, $Re_c = 1.5 \times 10^6$ and angle of attack, $\alpha = 14°$), inspired by the experimental setup of Coles & Woodcock (1979). We impose complex impedance boundary conditions (IBCs) using the implementation developed by Scalo, Bodart and Lele, *Phys. Fluids* **27**, 035107 (2015), representing an array of sub-surface-mounted tunable Helmholtz cavities with resonant frequency, f_{res}, covered by a porous sheet with permeability inversely proportional to the impedance resistance. Generation of spanwise-oriented Kelvin-Helmholtz (KH) rollers of size $l_{KH,0} \simeq U_\infty / f_{\text{res}}$is observed in areas of sustained mean shear, which are convectively amplified along the shear-layer and reenergizing the separated flow via vortical-induced mixing and entrainment of irrotational fluid. Their characteristic initial size $l_{KH,0}$ is determined by the periodic wall-transpiration pattern induced, in turn, by acoustic resonance in the cavities. Several resonant frequencies and impedance have been tested, bracketing optimal conditions for control.

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