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Direct Numerical Simulations of a Separating Turbulent Boundary Layer Subjected to Zero-Net-Mass-Flux Actuation[1] WEN WU, University of Mississippi, CHARLES MENEVEAU, RAJAT MITTAL, Johns Hopkins University, ALBERTO PADOVAN, CLARENCE ROWLEY, Princeton University — The response of a turbulent separation bubble (TSB) to zero-net-mass-flux actuations is investigated via DNS. The TSB is formed by applying a suction-only velocity profile on the top boundary. Streamwise-oriented actuators are placed upstream of the TSB to produce perturbations mimicking the Görtler vortices that cause a low-frequency unsteadiness of the TSB. The natural vortex-shedding frequency (f_h) and breathing/flapping frequency ($f_l = 0.4f_h$) of the undisturbed TSB are examined, as well as another one at $10f_l$. Compared with the undisturbed case, the TSBs under the actuation at f_h and f_l reattach earlier, leading to a 50% reduction in length and improved pressure recovery. The low-frequency unsteadiness is amplified, showing as a periodic formation of clockwise-rotating large vortices at f_l. Actuation at $10f_l$ barely changes the TSB and even causes more pressure loss. The response preference of the TSB to certain actuation frequencies is further discussed by a spectral analysis of a harmonic resolvent operator performed to a base flow that consists of the mean and the low-frequency unsteady motion. The preferred perturbation and the receptivity of the mean flow to actuation at different frequencies suggested by analysis are consistent with the DNS.

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