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Stability and resolvent analysis of a turbulent separation bubble

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We study the modal (self-excited) and non-modal (amplifier) dynamics of a mean turbulent separation bubble (TSB) forming over a flat plate via an artificial adverse pressure gradient. The flow configuration is in direct comparison to recent DNS and experimental studies. We reconstruct the two-dimensional turbulent mean-flow using the Reynolds-Averaged Navier Stokes (RANS) equations closed with a Spalart-Allmaras model. Linear stability analysis of the mean-flow reveals that the TSB is globally unstable to a steady three-dimensional mode which leads to a spanwise breakdown of the separated flow. The linear response of the TSB to harmonic forcing is then studied using resolvent analysis. At high frequencies ($St \sim 0.5$), the response reveals the non-modal amplification of structures related to the shedding of the shear-layer. At the low-frequency range, the response exhibits a low-pass filter behaviour, selectively amplifying frequencies up to a certain cut-off value and showing a peak at $St \sim 0.02$. This frequency is consistent with the well-documented bubble 'breathing' phenomenon that induces a periodic expansion and contraction of the separated flow.

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