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On the interaction among different instability modes in a transitional boundary layer under an accelerating/decelerating free stream[1]
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Results from a DNS of a flat-plate boundary layer that is subject to an elliptic leading edge and an accelerating followed by a decelerating free stream are presented. The free-stream acceleration is appreciably stronger than the critical levels required for relaminarization: $K = (\nu/U_\infty^2)dU_\infty/dx = 3.7 \times 10^{-6}$. Beneath these free-stream conditions - which are typical of the suction side of a low-pressure turbine blade - the predominant transition process can be classified into three regimes: *(i)* an initial zone where a separated shear layer forms near the leading edge and triggers a rapid growth of disturbances via an inviscid instability mode; *(ii)* a strongly accelerated intervening region where upstream structures are effectively frozen and disturbance amplitudes are depressed well below the levels required for the onset of secondary instability; *(iii)* a final zone where the decelerating free stream causes rapid transition without separation. Visualizations of flow structures inside zone *(iii)* suggest a coupling between viscous and helical instability modes. Identification of the helical modes is noteworthy; it has only been observed previously in boundary layers under elevated free-stream turbulence.

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