Excitation and evolution of subsonic Görtler vortices excited by elevated frees-tream vortical disturbances

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We study unsteady Görtler vortices excited by free-stream vortical disturbances (FSVD) in compressible boundary layers. The receptivity mechanism in the linear regime has been recently studied by Viaro and Ricco (2019)[1], who showed that compressible Görtler vortices are effectively induced by small-amplitude FSVD. In the present study, the focus is instead on the nonlinear development of compressible Görtler vortices exposed to elevated FSVD. The formation and evolution of the Görtler flow are governed by the compressible nonlinear boundary-region equations, supplemented by appropriate initial and boundary conditions which characterise the impact of the FSVD on the boundary layer. The curvature effect is studied for Görtler vortices excited by FSVD at different turbulence levels, up to $Tu = 6\%$, which refer to typical experimental conditions of turbomachinery applications[2]. It is found that low-frequency, i.e. long-wavelength, components of the FSVD are the primary factor in the generation of the Görtler vortices. Although the FSVD consists of vortical disturbances, thermal fluctuations are excited in the boundary layer because of the momentum-energy coupling caused by compressibility.

Figure 1(a) shows the downstream development of the maximum r.m.s. of the streamwise velocity at a relatively low turbulence level, $Tu = 1\%$. The concave wall (positive Görtler number $\mathcal{G}$) is found to destabilise the flow, whereas the convex wall (negative $\mathcal{G}$) has a stabilizing effect. At a higher turbulence level, $Tu = 6\%$, figure 1(b) shows that the nonlinearly saturated Görtler vortices are only influenced by a very strong wall curvature. The stabilisation effect of the convex wall becomes weak as the excited vortices experience considerable nonmodal growth near the leading edge of the convex wall.

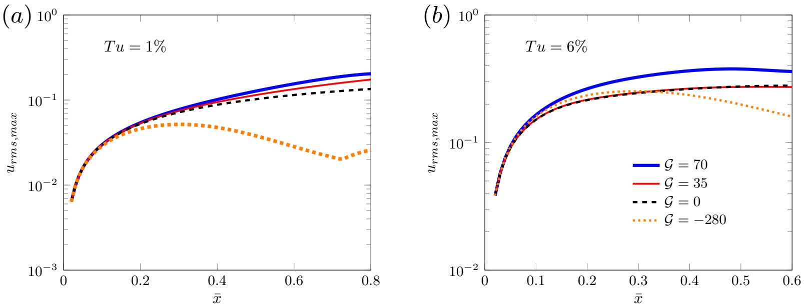

Figure 1: Development of the maximum r.m.s. of streamwise velocity. (*a*) $Tu = 1\%$; (*b*) $Tu = 6\%$. The parameters are $k_1 = 0.0073$ and $R_\Lambda = 1125$.

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[1] Viaro & Ricco, *J. Fluid Mech.* **867**, 250-299 (2019).

[2] Arts, T., Lambertderouvroit, M. & Rutherford, A. W., *Technical Note* **174**, (1990), van Kármán Institute.