Influence of Streamline Curvature on Compressible Turbulent Boundary Layers

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Direct numerical simulations (DNS) have been performed to investigate the effect of concave wall curvature on a compressible subsonic turbulent boundary layer (TBL). Concave wall curvature induces pressure gradients in the flow field in both the wall-tangential and wall-normal directions as required to achieve a momentum equilibrium with the centrifugal forces present in the turning flow. By comparison, a flat plate TBL with parallel oncoming flow has no significant mechanism for sustaining an appreciable wall-normal pressure gradient. The statistical properties of a curved wall TBL are therefore affected primarily as a result of the turning of the mean flow, also known as streamline curvature. Additionally, the gradient of angular momentum in the radial direction present in flows with streamline curvature allows for the formation of Görtler structures. The Görtler instability and its associated coherent structures are primarily relevant to transition of laminar boundary layers over concave walls, although in the fully turbulent regime they potentially serve to interact with large scale eddies.[1]

Multiple DNS of turbulent boundary layers over concave wall geometries will be presented. To isolate the effect of streamline curvature, analogous flat DNS cases have been run which achieve the equivalent mean wall pressure profile as in the geometrically curved cases, but without centrifugal and streamline curvature effects. Such is achieved through the specific construction of the streamwise freestream pressure profile at the wall-opposite domain boundary. The statistical properties of TBLs with mean flow streamline curvature and their flat, but barometrically equivalent counterparts will be compared for various curvature radii.

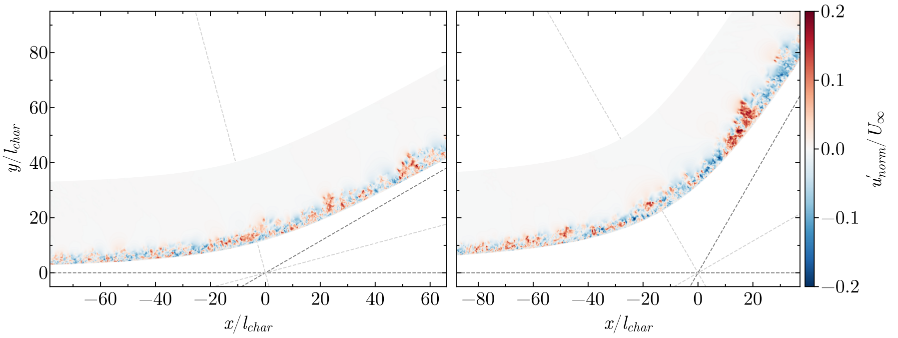

Figure 1: Instantaneous mean-removed wall-normal velocity for two wall curvatures.

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[1] Floryan, *Progress in Aerospace Sciences*, **28**, 235-271 (1991).