Investigation of near-wall scatter of scaled inflectional mean velocity profiles of turbulent separated flow over the Gaussian bump geometry

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Velocity profile scaling in turbulent separated flows has been investigated for the available experimental data of the smooth body separation experiment over the Boeing Gaussian bump. We investigated the mean velocity profile behaviour at the near wall area, where the Embedded Shear Layer (ESL) scaling failed to collapse the scattered profiles. The ESL scaling was modified to a new scaling, which we denote as Split Region ESL (SRESL). The new scaling accounts for two distinct regions governed by different flow parameters, above and below the inflection point in each mean velocity profile along the separation bubble. With the new SRESL scaling, an improved collapse of mean velocity profiles on top of each other was obtained, resembling the sigmoid function family. However, the transformed profiles still exhibit scatter in the near wall area. To understand the scattering behavior of SRESL profiles near the wall, we applied a Generalized Logistic Function (GLF) fit, which can match the shape of each scaled SRESL profile, and studied the fitted parameter trends along the separation bubble range to establish their relation to separated flow characteristics. The behavior of the parameters of the GLF fit was analyzed for experimental data at two freestream Mach numbers Ma = 0.1, and 0.2. Relations were established between several GLF parameters and physical quantity measurements of the flow, such as velocity at the inflection point, local free stream velocity, and the skin friction streamwise variation in separation bubble region. The observed relations exhibited similar trends across both Mach numbers that were examined. These established relations of GLF parameters to flow physics have the potential of representing a wide range of velocity profiles via an analytical function in a wide range of separated flow-field geometries and Reynolds numbers.

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