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Non-Unique Quasi-Equilibrium Turbulent Boundary Layers

Bernhard Scheichl, Alfred Kluwick

Institute of Fluid Mechanics and Heat Transfer, Vienna University of Technology, Vienna, Austria

Classical large Reynolds number asymptotics of turbulent boundary layers is consistent with the assumption that the Rotta–Clauser parameter is a quantity of $O(1)$. However, as known from, among others, similarity solutions, this parameter may be large or even tend to infinity under certain limiting conditions. It is the aim of the present investigation to show that also these cases can be covered by rigorous asymptotic analysis, which is essentially independent of the choice of a specific Reynolds stress closure. This requires the introduction of an additional small perturbation parameter which reflects the slenderness of the boundary layer and accounts for the then wake-like structure of the velocity profile. Most interestingly, in the specific case of quasi-equilibrium flow the transition from classical small-defect to a pronounced wake flow is associated with double-valued solutions, a phenomenon seen to agree well with early experimental observations.

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