The classical rational approach to turbulent wall-bounded shear flows in the limit of large Reynolds number *Re* has been extended in two directions which cope with different orders of magnitudes of the velocity defect with respect to the external potential flow.

Firstly, it was shown that the classical two-tiered boundary layer structure having a non-dimensional velocity deficit of $O((\ln Re)^{-1})$ is included as a special case of a more general theory which describes flows exhibiting a so-called moderately large velocity defect, [1]. As a highly remarkable consequence of the underlying three-tiered asymptotic splitting of turbulent boundary layers, the velocity deficit in the outermost main regime is found to be small and essentially independent of *Re*. Furthermore, the theory provides an explanation on a firm rational basis of the frequently observed phenomenon of non-uniqueness: for a single prescribed pressure distribution there exist two solutions which differ, among others, by the size of the velocity defect which then is of $O((\ln Re)^{-2/3})$, [1], [2]. Moreover, by adopting a time-averaging method which allows for the treatment of weakly unsteady flows the solution having a larger defect is proven to be unstable.

Secondly, and as the primary goal of the research project, an asymptotic theory of turbulent marginal separation has been devised, at least as far as outer wake-type regime of the boundary layer is concerned, [3]. In essence, this theory is based on the argument, strongly supported by the commonly applied turbulence closures, that the thickness of boundary layers having a velocity defect of $O(1)$ is measured by a small slenderness parameter α even in the limit of infinite Reynolds number. Combining this conclusion with rather weak assumptions regarding the local properties of the mixing length at the base of the wake regime allows for the development of a novel boundary layer theory, [3], where α serves as the principal perturbation parameter. If the imposed pressure gradient is chosen properly, the wall slip velocity forming in the double limit $1/Re = \alpha = 0$ under consideration vanishes at a single location but immediately recovers. This weakly singular behaviour resembles the well-known flow situation which leads to the concept of laminar marginal separation, if the slip velocity is replaced by the wall shear. However, in striking contrast to the laminar case, turbulent marginal separation is characterised by a strong acceleration of the flow downstream, which is associated with the occurrence of a specific non-trivial local eigensolution, [5]. In order to eliminate the singularity, which signals a breakdown of the hierarchical boundary layer concept where the pressure gradient is taken to be imposed, a weak interaction theory has been developed, [5], which accounts for the feedback effect of the external pressure induced by the locally rapidly changing boundary layer edge as separation is approached. Similar to the laminar case, the resulting elliptical fundamental problem appears to be controlled by a single similarity parameter. The numerical solutions confirm that the turbulent separation process is governed by non-trivial eigensolutions of that triple-deck problem. The associated spontaneous branching of the flow is triggered by the aforementioned non-trivial downstream state and has never been observed in conventional subsonic triple-deck flow configurations. As one future task, these numerical results showing pronounced closed reverse-flow regions are to be compared with data obtained both experimentally and by Direct Numerical Simulation.

[1] SCHEICHL, B. & KLUWICK, A. 2004 Non-unique turbulent boundary layer flows having a moderately large velocity defect. *J. Fluid Mech.*, submitted in revised form.

[2] SCHEICHL, B. & KLUWICK, A. 2004 Non-unique quasi-equilibrium turbulent boundary layers. In *Abstracts Book and CD-ROM Proceedings* to the *XXI ICTAM, 15–21 August 2004, Warsaw, Poland*.

[3] SCHEICHL, B. & KLUWICK, A. 2005 Non-Unique Self-Similar Turbulent Boundary Layers in the Limit of Large Reynolds Number. In *Progress in Turbulence* (ed. J. Peinke, M. Oberlack, A. Kittel & S. Barth). Springer Proceedings in Physics Vol. 110, Springer, pp. 111–116.

[4] SCHEICHL, B. & KLUWICK, A. 2004 On a novel wake-type limit of marginally separating turbulent boundary layers. *J. Fluid Mech.*, in preparation.

[5] SCHEICHL, B. & KLUWICK, A. 2005 Turbulent Marginal Separation and the Turbulent Goldstein Problem. Contribution for the *4th AIAA Theoretical Fluid Mechanics Meeting, 6–9 June 2005, Toronto, Canada* and considered for publication in *AIAA Journal*.