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Quantifying Reynolds stresses in the planar transitional T3-serious flows[1] FAN TANG, WEI-TAO BI, ZHEN-SU SHE, State Key Lab for Turb. & Complex Sys., College of Engg., Peking Univ. — The transitional flow with a rapid change of friction coefficient in the streamwise direction is a subject of enormous technological impact, but difficult to quantify, even for simple geometry such as flow passing a smooth flat plate. Recently, a comprehensive theory of turbulent boundary layer is constructed via a Lie-group symmetry approach, yielding a multi-layer description of four stress lengths in the wall-normal direction. Here, we report its extension to transitional TBL, with a unified quantitative description for both the Reynolds shear stress and normal stresses (turbulence intensities) throughout the transition region. Specifically, the transition and subsequent evolution to fully developed TBL are quantified with a streamwise multilayer description (starting from the leading edge) of two key parameters (a near-wall eddy length, and kappa – a bulk flow parameter), which display a scaling change from laminar to turbulent regime. For the T3-serious planar transitional flows with varying incoming turbulence intensity and pressure gradient covering both natural and bypass transitions, the new theory predicts simultaneously, for the first time, the friction coefficient and wall-normal mean (velocity and turbulent kinetic energy) profiles throughout the entire flow domain. In summary, all four Reynolds stress components are successfully predicted for transitional planar boundary layer, promising future simpler and more accurate transitional model for engineering applications.

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