Streamwise evolution of the interscale transport of energy-containing eddies in turbulent boundary layers

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Turbulent wall-bounded flows can be interpreted as a cluster of recurrent patterns of energy-containing eddies (energy-eddies).[1] These energy-eddies carry most of the momentum and kinetic energy and are considered to be the elementary structures needed to explain how momentum and kinetic energy are redistributed in wall-bounded turbulence. Although previous studies have demonstrated that energy-eddies are involved in a temporal self-sustainning cycle,[2,3,4] the specific issue of how energy-eddies generate and evolve appears to be an open question.

The aim of the present study is to investigate the spatial evolution and multi-scale interaction of energy-eddies in incompressible zero pressure gradient (ZPG) turbulent boundary layers (TBLs) by means of direct numerical simulation (DNS). To this end, the energy-eddies are removed at the inflow of a ZPG-TBL DNS and turbulent kinetic energy (TKE) and Reynolds shear stress transport are examined using the spanwise spectral decomposition introduced by Kawata and Alfredson.[5] The DNS setup consists of two concatenated domains, the auxiliary domain and the main domain, which are run synchronously.[6] The auxiliary domain runs at a lower resolution and is used to provide a realistic turbulent inflow to the main domain. The TKE transport term is used to identify the boundary that distinguishes the energy-eddies from the other eddies (cascading-eddies).[7] The separation between energy-eddies and cascading-eddies is found at $\lambda_z \approx 3y$ in agreement with previous studies in boundary-layers.[8] The fluctuations and energy in the wall-normal profile with $y \lesssim \lambda_z/3$ are removed at the inflow of the main domain at each time step. Preliminary flow field statistics will be presented addressing the spatial development and inter-scale transport mechanisms of energy-eddies in TBLs.

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[1] Ridchardson, *Weather Prediction*, Cambridge (1922).
[2] Hamilton et al, *J. Fluid Mech.* **317**, 287 (1995).
[3] Waleffe, *Phys. Fluids* **883**, 9 (1997).
[4] Jimenez and Pinelli, *J. Fluid Mech.* **335**, 389 (1999).
[6] Borrell et al., *Comp. Fluids* **37**, 80 (2013).
[7] Cho et al., *J. Fluid Mech.* **474**, 854 (2018).
[8] Chan et al., *J. Fluid Mech.* **A13**, 921 (2021).