Interscale transport mechanisms in the spatial evolution of energy-containing eddies

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In this study, energy-containing eddies (energy-eddies) at the inflow of a turbulent channel flow direct numerical simulation (DNS) are quenched and the interscale transport mechanisms in the spatial development of the energy-eddies is studied by employing the framework of Kawata and Alfredsson (2018)[1]. Two synchronised DNSs were used: a fully resolved streamwise periodic channel flow (PCH-DNS) and a fully resolved channel flow DNS with inflow-outflow boundary conditions (IOCH-DNS), where the inflow velocity field of the IOCH-DNS is a filtered version of the inflow from the PCH-DNS, with a convective outflow boundary condition applied at the domain exit[2]. The results of the study reveal a significant inverse cascade of streamwise Reynolds stress from near-wall streaks at a spanwise wavelength of $\lambda_z^+ \simeq 100$ to the large scales of wavelength $\lambda_z^+ \geq 200$, as shown in figure 1(c-f). This inverse cascade is a consequence of the spanwise gradient of streamwise fluctuations and points to streak instability. The results also demonstrate that the inverse cascade of spanwise energy may correspond to the regeneration of streamwise vortices, which can reactivate the self-sustaining process in the spatial evolution of energy-eddies.

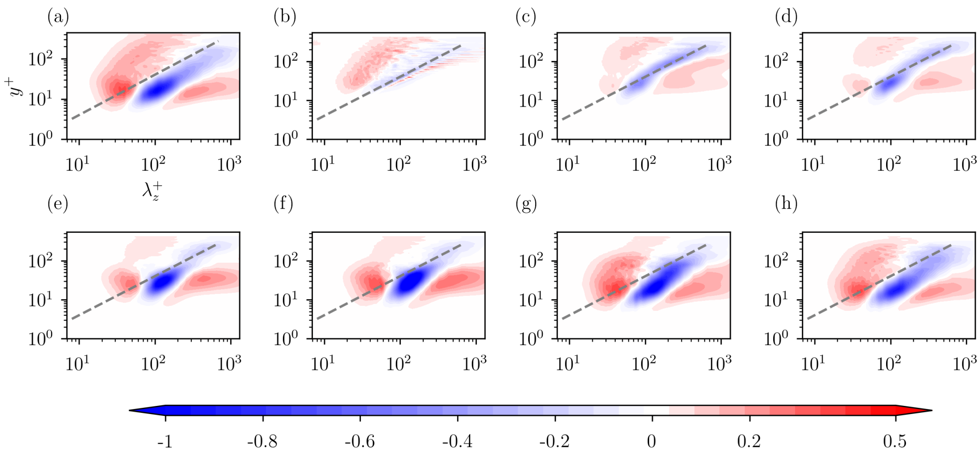

Figure 1: The one-dimensional premultiplied inter-scale transport of the streamwise Reynolds stresses in the spanwise wavenumber direction ($k_z y^+ t^+_{r_{uu}}$), at various streamwise locations: (a) PCH-DNS, (b) $x = 0h$, (c) $x = 1.5h$, (d) $x = 3h$, (e) $x = 6h$, (f) $x = 8h$, (g) $x = 12h$, (h) $x = 24h$. (a) PCH-DNS, (b, c, d, e, f, g, h, i) IOCH-DNS. Here, - - - is at $\lambda_z = 3y$ to indicate the cutoff spanwise wavelength.

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[1]Kawata and Alfredsson, *Phys. Rev. Lett.* **120**, 244501 (2018).

[2]Kannadasan, Atkinson and Soria, *J. Fluid Mech.* **955**, R1 (2023).