# Wall-bounded turbulence without self-sustaining process

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Self-sustaining process[1] (SSP) has been believed to be the building block mechanism for the generation of coherent structures in wall-bounded shear flows across all integral scales[2], and it is composed of three substeps: 1) generation of elongated streaks from streamwise rolls via the lift-up effect; 2) instability and/or transient growth of streamwise undulating wave around the amplified streaks; 3) breakdown of the streaks and the regeneration of streamwise rolls. Its mathematical structure admits the non-trivial exact solutions to the Navier-Stokes equations, which typically emerge via a saddle-node bifurcation.

Here we report a new type of sustaining process that enables to generate turbulence without SSP in the minimal flow unit of Couette flow. This process was discovered by applying a quasilinear approximation based on a decomposition of velocity into spanwise mean and the corresponding fluctuations (we refer to this as 'QLZ'). Similarly to SSP, this process may be decomposed into three substeps: 1) linear amplification of quasi-two-dimensional structures via the Orr mechanism; 2) instability or transient growth of a mode in the form of elongated streaks; 3) breakdown of the elongated streak mode and reinitiation of the Orr mechanism. This process, isolated by QLZ, also admits non-trivial exact solutions emerging through a saddle-node bifurcation, as shown in figure 1. The resulting upper-branch state, which ultimately initiates turbulence, was, however, found to have smaller skin friction than its counterpart from DNS and another quasilinear approximation based a decomposition of velocity into streamwise mean (QLX[3]) and the corresponding fluctuations. Healthy turbulence admitted by this process was also found to emerge at higher Reynolds numbers.

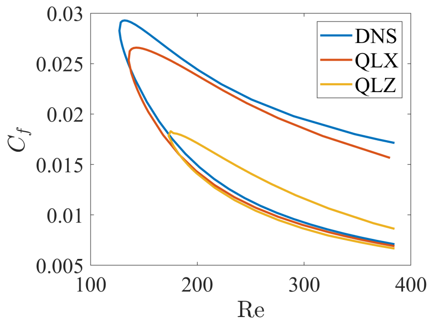


Figure 1: Bifurcation diagram of Nagata's equilibrium solution for DNS, QLX and QLZ in terms of the friction coefficient $C_f$.

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