On the generic role of vorticity stretching in three-dimensional transient growth of plane parallel shear flows

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ABSTRACT

Studies of non-modal transient disturbances growth in viscous plane parallel shear flows show that 3D perturbations always attain a larger temporal growth than 2D ones. Furthermore, this growth appears in later stages than in 2D. Recent computations for Couette, Poiseuille and mixing layer flows show that the optimal disturbance appears when isolines of the spanwise vorticity component are tilted with the mean shear. This stands in contrast with 2D growth where energy grows mostly via the Orr mechanism when the vorticity lines are tilted against the shear. It is found that in all cases the 3D growth results from vorticity stretching in the additional spanwise direction**.** By decomposing the optimal velocity disturbance projection onto the shear plane into the potential and rotational components, it is argued that its divergent-free part contributes mostly to the energy growth yielding a positive feedback between vorticity and velocity growth. The above phenomenon is observed numerically for viscous flows, as well as analytically for simplified inviscid model considering a linear Couette velocity profile.