Optimal two-dimensional perturbations in a stretched shear layer

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Abstract The evolution of 2D linear perturbations in a uniform shear layer stretched along the streamwise direction is considered in this work. The shear layer is assumed to have an error function profile. The width and strength of the shear layer evolve in time due to the combined effect of viscous diffusion and stretching. The time-dependent basic flow is therefore characterised by two parameters: the stretching rate γ and the Reynolds number Re. Using a direct-adjoint technique, perturbations which maximise the energy gain during a time interval $(0, t_f)$ are computed for various t_f, γ and Re. The results are compared with those obtained using a normal mode decomposition of the perturbations (WKBJ approach). Transient growths are shown to be weak in a stretched shear layer by opposition to what is observed in boundary layer flows.

A sheet that is stretched, in collusion
With limited viscous diffusion,
Upon a flat table,
Is grossly unstable;
But frankly, it's all a delusion.

1. Introduction

A vortex sheet during its roll-up or the braid region between two adjacent vortices in a shear flow are typical examples of shear layers stretched along the streamwise direction. The goal of this article is to determine under which conditions these stretched layers are unstable with respect to the Kelvin-Helmholtz instability.

Shear layers in a non-viscous flow have been known to be unstable with respect to two-dimensional perturbations since the works of Kelvin, Helmholtz and Rayleigh. Betchov & Szewczyk (1963) analysed the effect of viscosity and demonstrated that the instability extended down to zero Reynolds number. Using a WKBJ ansatz, they also took into account the weakly diffusing character of the shear layer and computed