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High Reynolds Channel Flows : Upstream Interaction of Various Wall Deformations

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ABSTRACT

This paper considers the upstream interaction of flows in a two-dimensional channel at high Reynolds number with wall deformations. An asymptotic model using the successive complementary expansion method with generalized asymptotic expansions, called GIBL for Global Interactive Boundary Layer [1, 3], is used. The aim is to analyse the asymptotic length Δ of the upstream influence of an *accident* at $x = x_0$ at the walls. As Smith [2] we first found that $\Delta = \mathrm{O}(\mathcal{R}^{1/7})$, where $\mathcal{R}$ is the Reynolds number. The only hypothesis on the wall *accident* is that it is significant enough to perturbe the Poiseuille flow, so that the Poiseuille flow is no more a good approximation in the boundary layer.
Then by assuming an exponential variation in x of the perturbed flow, in order to obtain the Poiseuille flow as $x \to -\infty$ (i.e. far upstream the wall deformations), we perform an eigenvalue analysis. We thus found that the first mode is related to non-symmetric wall deformations, and that the second one to symmetric wall deformations.
Various wall deformations are considered, such as troughs, bumps or elbows, and comparisons between GIBL, Navier-Stokes solutions and eigenmodes show that the model is well founded and enables us to relate the eigenmodes to the form of the *accident*. The special case of a symmetric deformation will be treated, and we noticed as Smith [4] that curiously more progress have been made for non-symmetric flows than for symmetric ones.

References

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