ABSTRACT:
The aim of this Bachelor’s Thesis is the study of a particular low-energy localized plane Poiseuille solution while minimizing the error introduced by the streamwise periodicity boundary condition. The fact that the instability of this shear ow is accepted to start as a 2D phenomenon, justifies the study of plane solutions that are much less computing power demanding. The main part of this work has consisted on very long time-integrations of the solution up to very long domains, and later, up to near critical Reynolds; while checking stability and performing various measurements. Finally, a domain-dependent mechanism describing the behaviour of very particular instabilities at high Re was found and analysed.

THEORY: PLANE POISEUILLE FLOW

Viscous, newtonian and incompressible fluid that is driven between two infinite parallel planes by a gradient of pressure. Imposing no-slip condition and constant pressure drop, there is an exact solution to the NS equations.

\[ \nabla \cdot u = 0, \]

This is solution is a strictly streamwise parabolic velocity field. It is known as the laminar solution or base flow.

OBJECTIVES:
• Determination of the stability of the solution at longer domains.
• Determination of the stability of the solution at higher Re.
• Determination of the mechanism of creation and evolution of those instabilities.
• Characterization of the periodic orbit of the solution.
• Do it in very long domains, minimizing the impact of streamwise periodicity

STAGES OF THE PROJECT:
1. Learning phase.
2. Dilatation and time integration of the solution.
3. Shift in Re in very long solutions from 2 and time integration.
4. Data analysis

METHODOLOGY:
• Numerical simulations conducted in UPC Applied Physics Department’s computer cluster
• Time-integration with Channelflow
• Data processing and plotting with Matlab
• Optimum grid configuration was determined via study of the spectral decay

INITIAL SOLUTION:
2D vorticity near the peak

DEPENDENCE WITH REYNOLDS:
• Flows with Re > 5300 were found to develop disturbances that grow into new similar travelling structures (instability).
• The seed of this instability are remnants that remain in the domain because of the streamwise periodicity. A basic mechanism was observed.
• These remnants are the consequence of discrete increases in Re: a modulation appears near the peak that travels along the trailing edge and is ejected into the laminar flow.
• When a traveling remnant communicates with the front, a new one of greater energy is born in the trail (causality confirmed).
• If the energy losses in the domain are smaller the the amplification in the crossing, eventually an energy threshold is achieved and a new secondary peak grows from the start of the trailing.

DEPENDENCE WITH THE LENGTH OF THE DOMAIN:
• After convergence issues wit Newton-Krylov-hookstep algorithm, stability of the solutions at very long lengths (up to L = 1684) was ensured with integration.
• No alterations were observed once stabilization after the disturbance introduced by dilatation.
• At longer domains, near machine precision is obtained and the profile of the disturbance is neater.
• Measurables of the flow have been found to change accordingly with the increase of “disturbance information” at greater lengths. Trails no longer united.

DEPENDENCE OF THE SOLUTION:

CONCLUSIONS:
• Trail waves are not TSWs
• Solution is stable at very long domains
• Trail dependence with Re
• Primary peak energy amplification of remnants

POSSIBLE CONTINUATIONS
• Implementing a filter against that ensures laminar flow preceding the front edge.
• Study of influenciability of secondary peaks