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Direct Numerical Simulations of subharmonic, fundamental and oblique transition in boundary layer

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1 Introduction

Transition to turbulence process in boundary layers may change the flow properties that affects the parameters in many practical applications. Transition still remains as an open problem in fluid mechanics. Transition may be triggered by infinitesimal perturbations, under unstable conditions, the flow amplifies these perturbations, initially linearly, and then, when disturbances reach a threshold amplitude, amplification occurs through the secondary instability mechanisms, that presents a moderate nonlinear behavior. Three of these mechanisms are known: K-type, H-type and Oblique transition. These mechanisms have been studied mainly in incompressible boundary layer on a flat plate. In this work, these mechanisms are simulated by Direct Numerical Simulations and are compared with experimental results reported in literature. Navier Stokes equations are solved numerically using compact finite differences with spectral like resolution [1] and Runge Kutta method for temporal integration. A modal analysis is performed using Discrete Fourier Transform (DFT). Growth rates and three-dimensional structures generated in each mechanism are disused in detail.

2 Partial results

Mechanisms of secondary instability are generated by adding controled perturbations in the boudary layer. Perturbation is composed by two or three waves. In particular, Fundamental resoanace is generated by a wave that propagates in the streamwise direction, usually denominated as fundamental mode,. and two oblique waves with opposite angles of propagation. Oblique waves have an amplitude infinitesimal in relation to the fundamental

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wave. All the three waves have the same frequency. In figure 1 is shown a comparison, in physical and Fourier space, between results reported in [2] with DNS simulations.

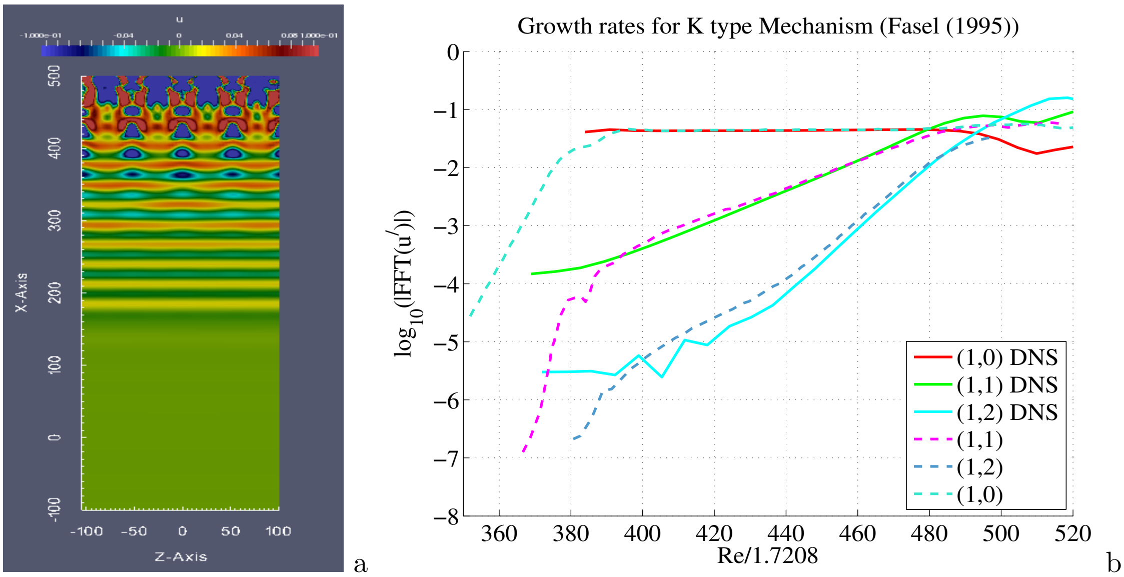

Figure 1: a. Three dimensional vortical structures generated in the K-type transition mechanism b.Growth rates of isolated modes. mechanism.

At the begining, the flow has a bidimensional structure, but when fundamental resoanace dominates a spanwise modulation generates three-dimensional vortices. Growth rates of oblique waves increases dramatically and finally reach same amplitude of fundamental wave.

3 Future work

Simulate and compare growth rates for subharmonic and oblique transition, and show in detail vortical structures generated in each mechanism.

References

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