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Instability and transition induced by wall roughness in a finite Stokes layer *

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The transition of a classic unsteady flow, namely, a Stokes layer, induced by wall roughness is investigated numerically. On the basis of numerical simulations using a semispectral method, a detailed analysis of the evolution characteristics of the disturbances is carried out. The results show that turbulence arises from the presence of large pre-existing two-dimensional waves accompanied by rapidly increasing three-dimensional waves. It is found that the 3D disturbances exhibit exponential growth prior to the onset of the transition, while the 2D disturbances reach a saturated state. The nonlinear growth rate of the 3D disturbances displays a linear relation to the spanwise wavenumber, with the fundamental spanwise wavenumber itself being connected to the appearance of the transition. The breakdown in the transition process is also analyzed, and similar to steady flows, an enhanced instability is found.

Keywords: Stokes layer, 3D disturbances, nonlinear growth rate, mean flow modification, breakdown

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1. Introduction

Understanding flows and how they transition towards the conditions of turbulence is important for a range of engineering applications. Previous investigations concerning laminar-turbulent transitions in plane channel flows have examined in close detail just how such transitions occur, and for the most part, the transition of steady flows is now well understood. However, in terms of understanding the transition behavior of unsteady flows, more research is still required to improve this understanding. As a step towards accomplishing this objective,

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