Abstract

The hydrodynamic stability and transition in fluid flows is an important field of research on which scientists have spent decades building methods to analyse the same. Reynolds, Rayliegh, Helmholtz and Kelvin are some of the few scientists in the nineteenth century who actually formulated and analysed some of the fundamental problems in hydrodynamic stability. It is a common practice in aircraft industries to approximate wings as flat plate within either an adverse or a favorable gradient of pressure. For such approximations, the development of boundary layer in favorable as well as adverse pressure gradients has to be thoroughly studied. Transition to turbulence is the result of growth of instabilities within the transition region. Hydrodynamic stability of laminar boundary layer when developed in the mathematical framework gives us insight to the wavenumber and frequency of unstable modes which are responsible for transition. Because of its stochastic nature, it is impossible to develop a mathematical theory for transition zone and therefore we rely on experiments and numerical simulations.

In this work we studied the relation between laminar instability and transition measurements in a zero and positive pressure gradient boundary layers to establish the connection. Orr Sommerfeld equation deals with instability in parallel flows when the instabilities are in its linear stage. This equation is solved using Chebychev collocation method to determine the most unstable modes. We then do LES simulations to try and capture such modes in the problem. We measured the transient wall pressure in the transition zone to establish the direct relation with laminar instability wave characteristics. Results indicate that the relation is prominent in adverse pressure gradient boundary