

Physics of transitional shear flows : instability and laminar–turbulent transition in incompressible near-wall shear layers

Boiko, Andrey V, author

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Abstrak

Starting from fundamentals of classical stability theory, an overview is given of the transition phenomena in subsonic, wall-bounded shear flows. At first, the consideration focuses on elementary small-amplitude velocity perturbations of laminar shear layers, i.e. instability waves, in the simplest canonical configurations of a plane channel flow and a flat-plate boundary layer. Then the linear stability problem is expanded to include the effects of pressure gradients, flow curvature, boundary-layer separation, wall compliance, etc. related to applications. Beyond the amplification of instability waves is the non-modal growth of local stationary and non-stationary shear flow perturbations which are discussed as well. The volume continues with the key aspect of the transition process, that is, receptivity of convectively unstable shear layers to external perturbations, summarizing main paths of the excitation of laminar flow disturbances. The remainder of the book addresses the instability phenomena found at late stages of transition. These include secondary instabilities and nonlinear features of boundary-layer perturbations that lead to the final breakdown to turbulence. Thus, the reader is provided with a step-by-step approach that covers the milestones and recent advances in the laminar-turbulent transition. Special aspects of instability and transition are discussed through the book and are intended for research scientists, while the main target of the book is the student in the fundamentals of fluid mechanics. Computational guides, recommended exercises, and PowerPoint multimedia notes based on results of real scientific experiments supplement the monograph. These are especially helpful for the neophyte to obtain a solid foundation in hydrodynamic stability.