Physics of Transitional Shear Flows

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Different aspects of instability and transition intended both for research scientists and for students in the field of fluid mechanics are discussed. Starting from fundamentals of classical stability theory, an overview is given of the transition phenomena in subsonic, wall-bounded shear flows [1]. At first, the presentation focuses on elementary small-amplitude velocity perturbations of laminar shear layers, i.e. instability waves, in the simplest canonical configurations. 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. The non-modal growth of local stationary and non-stationary shear flow perturbations as well as receptivity of convectively unstable shear layers to external perturbations are covered as well. The remainder 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. Computational results based on real scientific experimental data supplement the presentation. Thus, the presentation provides a step-by-step approach that covers the milestones and recent advances in the laminar-turbulent transition and is expected to be especially helpful for neophytes to obtain a solid foundation in hydrodynamic stability.

1. Boiko A.V., Dovgal A.V., Grek G.R., Kozlov V.V. Physics of Transitional Shear Flows. Dordrecht: Springer, 2012, 298 стр. (ISBN 978-94-007-2497-6, e-ISBN 978-94-007-2498-3).