POLITECNICO MILANO 1863

DIPARTIMENTO DI SCIENZE E TECNOLOGIE AEROSPAZIALI

Subcritical transition in wall-bounded shear flows

Jacob Cohen
Technion - Israel Institute of Technology

Abstract
The current study focuses on a sub-critical transition scenario of wall-bounded flows which are stable with respect to infinitesimal small disturbances (Couette flow and Plane Poiseuille flow for subcritical Reynold numbers). Accordingly, a linear transient growth mechanism is initiated by four decaying normal modes, the initial structure of which corresponds to counter-rotating vortex pairs. It is shown that the four modes, are enough to capture the transient growth mechanism. More importantly, it is demonstrated that the kinetic energy growth of the initial disturbance is not the key parameter in this transition mechanism. Rather, it is the ability of the transient growth process to generate an inflection point in the wall-normal or spanwise directions and consequently to make the flow susceptible to a three-dimensional disturbance leading to transition to turbulence. The model utilizes separation of scales between the slowly evolving base-flow and the rapidly evolving secondary disturbance. Because of the minimal number of modes participating in the transition process, it is possible to follow most of the key stages analytically, using the multiple time scales method. It is only due to nonlinear effects that the base flow becomes unstable with respect to an infinitesimal disturbance. The theoretical predictions are compared with direct numerical simulations and very good agreement with respect to the growth of the disturbance energy and associated vortical structures is observed, up to the final stage just before the breakdown to turbulence. Finally, the mechanism governing these transition stages (in the odd transition scenario) is very similar to the one described by the vortex dynamics model, previously proposed by the authors to explain the experimentally observed generation of a train of hairpins.

Bio
Jacob Cohen is a Professor and Sydney Goldstein Chair in Aeronautical Engineering at the Faculty of Aerospace Engineering, Technion – Israel Institute of Technology. He is the former Dean of the faculty (2015-2018) and currently serves as the head of the Technion Wind Tunnel Complex. Jacob received his Bachelor (1980) and Master (1982) degrees in Mechanical Engineering at the University of Tel-Aviv, Israel, and PhD (1986) at the AME department in University of Arizona. He then completed two and a half years as a Postdoc fellow at MIT before returning to Israel (Technion). His main research interests are in experimental, theoretical and numerical study of laminar-turbulent transition, study of the evolution and control of coherent structures in wall bounded and free shear flows, hydrodynamic and thermal instabilities and unsteady phenomena.

www.aero.polimi.it

2 April 2019 at 12:00
Building B12, Second Floor, Sala Consiglio DAER
Campus Bovisa
Politecnico di Milano
Via La Masa, 34 - 20156 Milano