European Research Council
Established by the European Commission

Università di Roma

Università di Roma Tor Vergata
Dipartimento di Fisica

Tor Vergata

Seminar

Thursday, 25 September 2014 - h. 14:30

Sala Paoluzi (Dipartimento di Fisica)

Prof. Ugo Piomelli

Department of Mechanical and Materials Engineering
Queen’s University - Kingston (ON) - CANADA

“Large-eddy simulations in dune-dynamics research”

Abstract

The flow over mobile sand beds in rivers has unique dynamics. Both the shape of the bed irregularities and their size influence the characteristics of the flow. When the dimensions of the bed irregularities become comparable to the water depth, large-scale turbulent structures are generated that affect flow dynamics and sediment transport. Among the most commonly found riverbed irregularities are dunes, created by small perturbations on a flat sand bed that grow until a large-scale form is established. They migrate in the flow direction and rarely reach an equilibrium shape, unless the flow is steady and unidirectional. In such case, however, an equilibrium state for the near-bed flow over developing dunes is found, and the flow characteristics are the same for various flow conditions and dune geometries. We discuss the recent use of large-eddy simulations (LES) for the analysis of the flow over dunes. In LES the governing equations of fluid motion are solved on a grid sufficiently fine to resolve the largest eddies, while the effect of the smallest ones is modelled. While LES has a long history in the environmental sciences (in particular, meteorology), and in mechanical and aerospace engineering, its use for the study of dune dynamics is more recent: the first simulations of this type are less than 10 years old. We have applied LES to the study of two and three-dimensional dunes, at laboratory scale, focusing on the relation between the largest coherent eddies, which are generated in the separated shear layer due to the Kelvin–Helmholtz instability; as they are advected, they undergo lateral instabilities and develop into horseshoe-like structures, are tilted downward, and finally reach the surface. The ejection that occurs between the legs of the vortex creates the upwelling and down-drafting events on the free surface known as “boils.” Near-wall turbulence, after the reattachment point, is affected by large streamwise Taylor–Görtler vortices generated on the concave part of the upward slope, which affect the distribution of the near-wall streaks. When the crest is three-dimensional, the separation of flow at the crestline alters the distribution of wall pressure, which in turn may cause secondary flows across the stream, which direct low-momentum fluid, near the bed, toward the lobe (the most downstream point on the crestline) and high-momentum fluid, near the top surface, toward the saddle (the most upstream point on the crestline). The mean flow is characterized by a pair of counter-rotating streamwise vortices, with core radius of the order of the flow depth.

ERC Advanced Grant (N. 339032) “NewTURB”
(P.I. Prof. Luca Biferale)
Università degli Studi di Roma Tor Vergata
C.F. n. 80213750583 – Partita IVA n. *02133971008* - Via della Ricerca Scientifica, 1 – 00133 ROMA