ROUGH WALLS TURBULENCE

P. Orlandi
Dipartimento di Ingegneria Meccanica e Aerospaziale
Università La Sapienza, Via Eudosiana 16, I-00184, Roma

October 19, 2016

DNS (Direct Numerical Simulations) of flows in channels are presented to demonstrate that the wall-normal Reynolds stress is a fundamental quantity to assess when the flow past smooth and rough surfaces becomes turbulent. In this paper, it is demonstrated that only when $\widetilde{u_2}^+|_w$ ($\widetilde{u_2} = \langle u_2'^2 \rangle^{1/2}$, $+$ indicates wall units and w the value at the plane of the crest of the roughness elements) is greater than the threshold value of 0.6 there is a transition from a laminar to a turbulent regime. This statement has been checked by changing the shape, the density and the distribution of solid obstacles. For fully turbulent channel the proportionality between $\widetilde{u_2}^{2+}|_w$, and the roughness function, obtained in DNS and experiments allows to derive a simple expression for the velocity profile in the log region. From this expression a new kind of Moody diagram, useful in the prediction of friction factors of rough flows at high Reynolds numbers, is proposed. It has been also checked that in the turbulence closure based on the Spalart-Almaras model for flow over rough surfaces the $\nu_T|_w \approx \widetilde{u_2}^{4+}|_w$ obtained by the present data can be useful. The analysis has been also extended to rough flows inside circular pipes. Analogies and differences have been exploited for the equal shape form of the roughness surfaces.

The influence of rough surfaces on the heat transfer has been also investigated by simulating also the interaction with the thermal field inside the solid wall. Results will be also presented for natural convection flows generated by heated surfaces of complex shape. To have insight on the physics of heat transfer the impact of high temperature vortex rings and vortex dipoles with complex surfaces will be simulated.

1 CV

Prof. Paolo Orlandi was born in Roma Jul. 11th 1944. Since 1985 he was Full Professor in Turbulence Modeling in the Facolta' di Ingegneria dell' Universita' di Roma La Sapienza. Now is doing research for pleasure without students and grants. He is fellow of the American Physical Society (APS) and member of the European Society of Mechanics (EUROMECH). From 1987 up to 2006 he was a member of the scientific committee of ERCOFTAC. From 1985 up to 2002 he was visiting professor of the Center for Turbulence Research at University of Stanford and of the NASA AMES Research Center. He has been chairman of the EUROMECH Colloquium on vorticity dynamics and the editor of the proceedings. He organised several ERCOFTAC workshops. He is associated editor of Applied Mechanics Review. He has published 46 papers on international journals about wall turbulence and vorticity dynamics. In 1996 he published a review paper written on invitation about vorticity/wall interactions, and in 2003 on the small scale of passive scalars in turbulence. He has published a book on munerical methods for fluid dynamics edited by Springler and entitled "Fluid Flow Phenomena: a numerical toolkit". His papers have been cited approximately 5000 times and his h factor is 33, as it appears in GOOGLE Scholar