

Progress in Wall Turbulence 2

ERCOFTAC SERIES

VOLUME 23

Series Editor

Bernard Geurts

*Faculty of Mathematical Sciences, University of Twente, Enschede,
The Netherlands*

Aims and Scope of the Series

ERCOFTAC (European Research Community on Flow, Turbulence and Combustion) was founded as an international association with scientific objectives in 1988. ERCOFTAC strongly promotes joint efforts of European research institutes and industries that are active in the field of flow, turbulence and combustion, in order to enhance the exchange of technical and scientific information on fundamental and applied research and design. Each year, ERCOFTAC organizes several meetings in the form of workshops, conferences and summerschools, where ERCOFTAC members and other researchers meet and exchange information.

The ERCOFTAC Series will publish the proceedings of ERCOFTAC meetings, which cover all aspects of fluid mechanics. The series will comprise proceedings of conferences and workshops, and of textbooks presenting the material taught at summerschools.

The series covers the entire domain of fluid mechanics, which includes physical modelling, computational fluid dynamics including grid generation and turbulence modelling, measuring-techniques, flow visualization as applied to industrial flows, aerodynamics, combustion, geophysical and environmental flows, hydraulics, multiphase flows, non-Newtonian flows, astrophysical flows, laminar, turbulent and transitional flows.

More information about this series at <http://www.springer.com/series/5934>

Michel Stanislas · Javier Jimenez
Ivan Marusic
Editors

Progress in Wall Turbulence 2

Understanding and Modelling

 Springer

Editors

Michel Stanislas
LML UMR 8107
Ecole Centrale de Lille
Villeneuve d'Ascq
France

Ivan Marusic
Mechanical Engineering
University of Melbourne
Parkville, VIC
Australia

Javier Jimenez
E.T.S. Ingenieros Aeronauticos
Polytechnic University of Madrid
Madrid
Spain

ISSN 1382-4309
ERCOFTAC Series

ISBN 978-3-319-20387-4
DOI 10.1007/978-3-319-20388-1

ISSN 2215-1826 (electronic)

ISBN 978-3-319-20388-1 (eBook)

Library of Congress Control Number: 2015945138

Springer Cham Heidelberg New York Dordrecht London
© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media
(www.springer.com)

Preface

This book brings together contributions from participants of the second WALLTURB workshop on “Understanding and modelling of wall turbulence” held in Lille (France) from June 18 to 20, 2014.

This workshop follows the inaugural workshop organized in 2009 by the WALLTURB EC project, and aimed to assess the progress made in the field of near-wall turbulence in the 5 years separating the two workshops.

The workshop assembled 60 participants from all over the world, with 6 invited lecturers and 39 contributions, and provided an opportunity to review the recent progress in theoretical, experimental and numerical approaches to wall turbulence.

This book gathers papers from most of the contributors to the workshop. It is aimed as being a milestone in the research field, thanks to the high level of invited speakers and the involvement of the contributors.

Lille
Madrid
Melbourne
August 2009

Michel Stanislas
Javier Jimenez
Ivan Marusic

Contents

Part I Invited Lectures

On the Size of the Eddies in the Outer Turbulent Wall Layer: Evidence from Velocity Spectra	3
Sergio Pirozzoli	
Sensitized-RANS Modelling of Turbulence: Resolving Turbulence Unsteadiness by a (Near-Wall) Reynolds Stress Model.	17
Suad Jakirlić and Robert Maduta	
Coherent Structures in Wall-Bounded Turbulence	37
Javier Jiménez and Adrián Lozano-Durán	
Attached Eddies and High-Order Statistics	47
Ivan Marusic and James D. Woodcock	

Part II Papers

DNS of Turbulent Boundary Layers in the Quasi-Laminarization Process	63
Guillermo Araya, Luciano Castillo and Fazle Hussain	
Numerical ABL Wind Tunnel Simulations with Direct Modeling of Roughness Elements Through Immersed Boundary Condition Method	73
Bruno Lopez, Gabriel Usera, Gabriel Narancio, Mariana Mendina, Maritn Draper and Jose Cataldo	

Three-Dimensional Nature of 2D Hairpin Packet Signatures in a DNS of a Turbulent Boundary Layer	83
S. Rahgozar and Y. Maciel	
Wall Pressure Signature in Compressible Turbulent Boundary Layers	93
N.A. Buchmann, Y.C. Küçükosman, K. Ehrenfried and C.J. Kähler	
Three-Dimensional Structure of Pressure–Velocity Correlations in a Turbulent Boundary Layer	103
Yoshitsugu Naka, Michel Stanislas, Jean-Marc Foucaut, Sebastien Coudert and Jean-Philippe Laval	
Computation of Complex Terrain Turbulent Flows Using Hybrid Algebraic Structure-Based Models (ASBM) and LES	115
C. Panagiotou, S.C. Kassinos and D. Grigoriadis	
Computation of High Reynolds Number Equilibrium and Nonequilibrium Turbulent Wall-Bounded Flows Using a Nested LES Approach	125
Yifeng Tang and Rayhaneh Akhavan	
An Attempt to Describe Reynolds Stresses of Turbulent Boundary Layer Subjected to Pressure Gradient	137
Artur Drózdź and Witold Elsner	
The Temporal Coherence of Prograde and Retrograde Spanwise Vortices in Zero-Pressure Gradient Turbulent Boundary Layers	147
Callum Atkinson, Vassili Kitsios and Soria	
Boundary Layer Vorticity and the Rise of “Hairpins”	159
Peter S. Bernard	
On the Extension of Polymer Molecules in Turbulent Viscoelastic Flows: Statistical and Tensor Investigation	171
Anselmo Soeiro Pereira, Ramon Silva Martins, Gilmar Mompean, Laurent Thais and Roney Leon Thompson	
Velocity of Line Plumes on the Hot Plate in Turbulent Natural Convection	181
Vipin Koothur and Baburaj A. Puthenveetil	

LES of a Converging–Diverging Channel Performed with the Immersed Boundary Method and a High-Order Compact Discretization 191
 Mariusz Ksiezzyk and Artur Tylizszczak

On Minimum Aspect Ratio for Experimental Duct Flow Facilities 201
 Ricardo Vinuesa, Eduard Bartrons, Daniel Chiu, Jean-Daniel Rüedi, Philipp Schlatter, Aleksandr Obabko and Hassan M. Nagib

Riblets Induced Drag Reduction on a Spatially Developing Turbulent Boundary Layer 213
 Amaury Bannier, Eric Garnier and Pierre Sagaut

Characterization of Pipe-Flow Turbulence and Mass Transfer in a Curved Swirling Flow Behind an Orifice 225
 N. Fujisawa, R. Watanabe, T. Yamagata and N. Kanatani

Turbulent Structure of a Concentric Annular Flow 237
 Sina Ghaemi, Majid Bizhani and Ergun Kuru

Reconstruction of Wall Shear-Stress Fluctuations in a Shallow Tidal River 247
 Romain Mathis, Ivan Marusic, Olivier Cabrit, Nicole L. Jones and Gregory N. Ivey

Analysis of Vortices Generation Process in Turbulent Boundary Subjected to Pressure Gradient 259
 Artur Drózdź and Witold Elsner

Experimental Investigation of a Turbulent Boundary Layer Subject to an Adverse Pressure Gradient at Re_θ up to 10000 Using Large-Scale and Long-Range Microscopic Particle Imaging 271
 Tobias Knopp, Nicolas A. Buchmann, Daniel Schanz, Christian Cierpka, Rainer Hain, Andreas Schröder and Christian J. Kähler

The Structure of APG Turbulent Boundary Layers 283
 Ayse G. Gungor, Yvan Maciel and Mark P. Simens

Adverse Pressure Gradients and Curvature Effects in Turbulent Channel Flows 295
 A.B. de Jesus, L.A.C.A. Schiavo, J.L. Azevedo and J.-P. Laval

On the Response of a Separating Turbulent Boundary Layer to High Amplitude Excitation	307
Vitali Palei and Avi Seifert	
Statistical and Temporal Characterization of Turbulent Rayleigh-Bénard Convection Boundary Layers Using Time-Resolved PIV Measurements	317
Christian E. Willert, Ronald du Puits and Christian Resagk	
Large-Scale Organization of a Near-Wall Turbulent Boundary Layer	335
R. Dekou, J.-M. Foucaut, S. Roux and M. Stanislas	
Near-Wall Study of a Turbulent Boundary Layer Using High-Speed Tomo-PIV	347
Fabio J.W.A. Martins, Jean-Marc Foucaut, Luis F.A. Azevedo and Michel Stanislas	
The Effects of Superhydrophobic Surfaces on Skin Friction Drag	357
Hyunwook Park and John Kim	
Structure and Dynamics of Turbulence in Super-Hydrophobic Channel Flow	367
Amirreza Rastegari and Rayhaneh Akhavan	
Spectral Assessment of the Turbulent Convection Velocity in a Spatially Developing Flat Plate Turbulent Boundary Layer at Reynolds Number $Re_\theta = 13\,000$	379
Nicolas Renard, Sébastien Deck and Pierre Sagaut	
Statistics of Single Self-sustaining Attached Eddy in a Turbulent Channel	391
Yongyun Hwang	
Scaling the Internal Boundary Layer	399
Fanxiao Meng, Donald J. Bergstrom and Bing-Chen Wang	
3D Spatial Correlation Tensor from an L-Shaped SPIV Experiment in the Near Wall Region	405
Jean-Marc Foucaut, Christophe Cuvier, Sebastien Coudert and Michel Stanislas	

**On Objective and Non-objective Kinematic Flow
Classification Criteria** 419
Ramon S. Martins, Anselmo S. Pereira, Gilmar Mompean,
Laurent Thais and Roney L. Thompson

**Quantification of the Full Dissipation Tensor from
an L-Shaped SPIV Experiment in the Near Wall Region.** 429
Jean-Marc Foucaut, Christophe Cuvier, Michel Stanislas
and William K. George