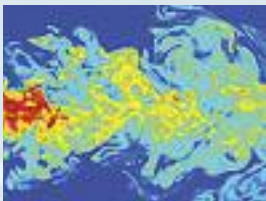


WHITHER TURBULENCE AND BIG DATA

FOR THE 21ST CENTURY

Symposium held at the
Institute d'Études Scientifiques de Cargèse
CORSICA, FRANCE

APRIL 20-24, 2015



Whither Turbulence and Big Data for the 21st Century

Symposium Chairman

Luciano Castillo, PhD
Texas Tech University, USA

Symposium Co-Chairman

Luminita Danaila, PhD
Université de Rouen, France

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University of Poitiers, France

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Whither Turbulence Big Data for the 21st Century

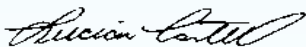
On behalf of the Organizing and Scientific Committees we would like to welcome you to the symposium **Whither Turbulence and Big Data in the 21st Century** and to celebrate the career achievements of our dear friend Bill George on his 70th Birthday. Moreover, the symposium represents a follow-up of the 1989 symposium organized by Prof. J. Lumley to address key fundamental questions in turbulence. Lumley's volume provided a compendium of the state of the art in our understanding of turbulence as at 1989.

Research into the flow physics of turbulence has grown drastically over the past 25 years in part due to the advances in computational fluid dynamics and new experimental capabilities. Yet, its growth is not at a rate one would like, especially in terms of societal impacts. The importance of turbulence is evident in many of the application areas that play significant roles in our daily lives. For example, energy, weather forecast, bio-fluids, aerospace industry and micro-climate modeling for urban flows. The advent of supercomputers and time resolved PIV and PTV have led to the production and acquisition of an unprecedented large amounts of high quality data which require new data mining approaches and new theories such as the ones spearheaded by Bill George and others since Lumley's 1989 Symposium. We expect new challenges and opportunities to emerge from this new confrontation between theory and data with eventual societal impacts.

One challenge that has emerged is the amount of data generated that is in the order of multiple terabytes. Moreover, the problem of turbulence is not only present in our daily lives, but is one of multiple scales in nature, ranging from micro to scales of the order of kms in the case of atmospheric flows. Not only do we still have the challenge of the spectrum of scales, we also have the challenge of how one integrates such multiple scales in a way that will enable accurate prediction of large-scale motions while also resolving with high fidelity the dissipative scales.

Consequently, during 5 days of the symposium in-depth discussion and talks we hope to provide a stimulating yet relaxed intellectual environment to identify key questions in the 21st century and how we will deal with the challenge of big databases. The symposium includes short talks each of 30 minutes (20 minutes talk, plus 10 minutes for discussion and transition). Daily in-depth discussions at the end of each day are designed to encourage maximum interaction among participants to help address the key objectives of the symposium.

Sincerely,



Luciano Castillo, PhD
Texas Tech University



BILL
GEORGE 70TH BIRTHDAY

Whither Turbulence and Big Data for the 21st Century

Honoring W.K. George
on occasion of his 70th birthday

During the 5-day event, we will address key fundamental questions in turbulence for the 21st century. Specifically we seek to deal with the pressing issue of “big data” in turbulence. In



addition, we will gather to honor and celebrate Bill George’s 70th Birthday. For more than half a century our esteemed friend pushed the tough questions and challenged well-known fundamentals in our fields. Thus, during the 5-day symposium his legacy will serve as inspiration to ask the tough questions and set a vision for the 21st century for turbulence and its role in our daily lives.

Monday, April 20

7:45 - 8:30

Registration

8:30 - 9:00 AM

Welcome:

Goals & Objectives of the Symposium

Luciano Castillo, *Texas Tech University*

Luminita Danaila, *University of Rouen*

Session #1A- Turbulence, Then, Now and Future

Session Chair:

Andrew Pollard, *Queen's University*

9:00 - 9:30 AM

A Brief History of WKG- A Legacy

Roger Arndt, *University of Minnesota*

9:30 - 10:00 AM

Turbulent Wakes. From Tennekes & Lumley, to Townsend and to George: A Slow March to Freedom

Christos Vassilicos, *Imperial College*

T. Dairay, *Imperial College*

M. Obligado, *Imperial College*

10:00 - 10:30 AM

Measuring Turbulence Power Spectra with LDA - Pushing the Limits

Preben Buchaven, *DTU*

Clara M. Velte, *DTU*

10:30 - 11:00 AM **COFFEE BREAK**

Session #2A- Turbulence Control

Session Chair:

Fernando Grinstein, *Los Alamos National Laboratory*

11:00 – 11:30 AM

Physical Mechanisms of Turbulence Control

Jean-Paul Bonnet, *University of Poitiers*

Bernd Noack, *University of Poitiers*

11:30 - 12:00 PM

Closed-loop Turbulence Control Using Machine Learning

Bernd Noack, *University of Poitiers*

Laurent Cordier, *Institute PPRIME, France*

Vladimir Parezanovic, *Institute PPRIME, France*

Jean-Paul Bonnet, *Institute PPRIME, France*

Markus W. Abel, *University of Potsdam, Germany*

Thomas Duriez, *Universidad de Buenos Aires, Argentina*

Steven Brunton, *University of Washington, USA*

12:00 – 12:30 PM

Turbulence Flow Physics and Control: The Role of Big Data Analysis Tools

Mark Glauser, *Syracuse University*

J. Lewalle, *Syracuse University*

M. Green, *Syracuse University*

R. Sureshkumar, *Syracuse University*

J. Dannenhoffer, *Syracuse University*

P. Varshney, *Syracuse University*

T. Wimalajeewa, *Syracuse University*

K. Kim, *Hanbat University*

12:30 - 1:30 PM **LUNCH**

Session #3A- Turbulent Boundary Layers I

Session Chair:

Martin Wosnik, *University of New Hampshire*

Michel Stanislas, *École Centrale de Lille*

2:00 - 2:30 PM

Coinciding Features in a Turbulent Boundary Layer via Lagrangian Coherent Structures, Dynamic Mode Decomposition and Proper Orthogonal Decomposition

Raul Cal, *Portland State University*

N. Ali, *Portland State University*

M. Tutkun, *Institute for Energy Technology, Kjeller*

2:30 - 3:00 PM

Evolution of Turbulent Boundary Layers from Different Tripping Conditions

Ivan Marusic, *University of Melbourne*

Kapil Chauhan, *University of Melbourne*

V. Kaluandaivelu, *University of Melbourne*

3:00 - 3:30 PM

Direct Numerical Simulation of a Self Similar Adverse Pressure Gradient Turbulent Boundary Layer

Julio Soria, *Monash University*

V. Kitsios, *Monash University*

C. Atkinson, *Monash University*

J. A. Sillero, *Universidad Politécnica de Madrid*

G. Borrell, *Universidad Politécnica de Madrid*

A. G. Gungor, *ITU Faculty of Aeronautics and Astronautics*

J. Jiménez, *Universidad Politécnica de Madrid*

3:30 - 4:00 PM

DNS of Turbulent Boundary Layers Subject to Strong Acceleration

Luciano Castillo, *Texas Tech University*

Guillermo Araya, *Texas Tech University*

Fazle Hussain, *Texas Tech University*

4:00 - 4:30 PM

COFFEE BREAK

Session #4A- Simulations and Fluid Dynamics

Session Chair:

Christos Vassilicos, *Imperial College*

4:30 - 5:00 PM

DNS of Turbulent Viscoelastic Channel Flow: Drag Reduction Mechanism and Dynamics

Tom Gatski, *Old Dominion University*

L. Thais, *Université de Lille Nord de France*

G. Mompean, *Université de Lille Nord de France*

5:00 - 5:30 PM

A Minimal Flow Unit for Turbulence, Combustion and Astrophysics

Paolo Orlandi, *University of Rome, La Sapienza*

5:30 - 6:00 PM

Bio-Mixing by Benthic Animals

Community Talk:

Paul Larsen, *DTU*

RECEPTION in Honor of Bill George & 70th Birthday Celebration

7:00 – 10:00PM

Welcome:

Luciano Castillo, *Texas Tech University*

Luminita Danaila, *University of Rouen*

Toast- Birthday & Career Legacy

Preben Buchaven, *DTU*

Mark Gluaser, *Syracuse University*

Stories to Share about Bill George

Tuesday, April 21

8:50 AM **Welcome Day #2:**

Luciano Castillo, *Texas Tech University*

Session #1B- Turbulent Structures & Jet

Session Chair:

Joe Cintriniti, *Corning*

9:00 - 9:30 AM

Turbulence and Data Analytics in the 21st Century: The Round Free Jet

Philippe Lavoie, *University of Toronto*

Hamed Sadeghi, *University of Toronto*

Andrew Pollard, *Queen's University at Kingston*

9:30 - 10:00 AM

The Sound-field Produced by Clustered Rockets During Start-up

Charles Tinney, *University of Texas-Austin*

A. Canchero, *University of Texas-Austin*

R. Rojo, *University of Texas-Austin*

N. E. Murray, *University of Mississippi*

J. H. Ruf, *NASA Marshall Space Flight Center*

10:00 – 10:30 AM

Self Similarity of Variable Viscosity Jets

Luminita Danaila, *University of Rouen*

10:30 - 11:00 AM **COFFEE BREAK**

Session #2B- Turbulent Boundary Layers II: Rough Surface

Session Chair:

Ivan Marusic, *University of Melbourne*

11:00 - 11:30 AM

Vorticity Dynamics in the Roughness Sublayer of Turbulent Flow Over a Streamwise-elongated Topography

William Anderson, *University of Texas- Dallas*

Ankit Awasthi, *University of Texas- Dallas*

Mohammad Aliakbari, *University of Texas- Dallas*

Julio M. Barros, *University of Notre Dame*

Kenneth T. Christensen, *University of Notre Dame*

11:30 - 12:00 PM

On the Turbulence Development over Geophysical-scale Topographies

Leonardo Chamorro, *University of Illinois Urbana-Champaign*

Ali Hamed, *University of Illinois at Urbana-Champaign*

Luciano Castillo, *Texas Tech University*

12:00 - 12:30 PM

Framework for Unsteady Turbulent Flows Over Rough Surfaces: Lab Scales to Atmospheric Scales

Kiran Bhaganagar, *University of Texas- San Antonio*

12:30 - 1:30 PM **LUNCH**

Session #3B- High Reynolds Numbers

Session Chair:

Murat Tutkun, *University of Oslo*

1:30 – 2:00 PM

Space-time 3D Pressure-velocity Correlations in a High Reynolds Number Turbulent Boundary Layer

Michel Stanislas, *Ecole Centrale de Lille*

Y. Naka, *Tokyo Institute of Technology*

J.-M. Foucaut, *Ecole Centrale de Lille*

2:00 - 2:30 PM

The Streamwise Turbulence Intensity in the Intermediate Layer of High Reynolds Turbulent Pipe Flow

Jean-Philippe Laval, *University of Lille*
J. C. Vassilicos, *Imperial College London*
J.-M. Foucaut, *University of Lille*
M. Stanislas, *University of Lille*

2:30 - 3:00 PM

Hydro-acoustic Instabilities in High Speed Turbulent Boundary Layers

Carlo Scalo, *Purdue University*

3:00 - 3:30PM

Turbulence and Oblique Shock-boundary Layer Interaction at High Reynolds Number - Physics and Modeling

Marianna Braza, *Institute de Mecanique des Fluides de Toulouse*
D. Szubert, *Institut de Mécaniques des Fluides de Toulouse*
Y. Hoarau, *Laboratoire des sciences de l'Ingénieur*
I. Asproulias, *Institut de Mécaniques des Fluides de Toulouse*

3:30 – 4:00 PM COFFEE BREAK

**Session #4B-
Atmospheric Flows & Theory**

4:00 - 5:00 PM

Session Chair:

Donald Bergstrom, *University of Saskatchewan*

4:00 – 4:30PM

Large Eddy Simulation of Environmental Flows: From the Laboratory Scale Toward Real Scale Applications

Vincenzo Armenio, *Università di Trieste*

4:30 - 5:00 PM

Wind Speed Spectral Characterization of the Lower Atmospheric Boundary Layer Over the Southwestern End of the US Great Plains

Region using Circadian Sodar Data
Arquimedes Ruiz-Columbie, *Texas Tech University*
V. P. Kiliyanpilakkil, *North Carolina State University*

S. Basu, *North Carolina State University*

G. Araya, *Texas Tech University*

Luciano Castillo, *Texas Tech University*

B. Hirth, *Texas Tech University*

W. Burgett, *Texas Tech University*

5:00 – 5:30 PM

Using Data and Theory Intensive Experiments to Stress-test Universal Equilibrium

Clara Velte, *DTU, Azur Hodzic, DTU*
Maja Wanstrom, *SMHI*
Knud Erik Meyer, *DTU*
William K. George, *Imperial College*

Session #5B-

Discussion #1: Challenges in Turbulence in the 21st Century-

What problems we should focus on in the next 20 years?

5:30 - 6:30 PM

Session Chair:

Julio Soria, *Monash University*

Fazle Hussain, *Texas Tech University*

Dinner in a Restaurant

7:00 – 10:0PM

Welcome:

Luminita Danaila, *University of Rouen*

Wednesday, April 22

8:20 AM **Welcome:** Day #3:

Luciano Castillo, Texas Tech University

Session #1C- Turbulence Theory

Session Chair:

Jean-Paul Bonnet, University of Poitiers

8:30 - 9:00 AM

Reduced-order Modeling of the Flow Around a High-lift Configuration with Unsteady Coanda Blowing

Richard Semaan

Institute of Fluid Mechanics, TU Braunschweig

Pradeep Kumar, *Institute of Fluid Mechanics, TU Braunschweig*

Marco Burnazzi, *Institute of Fluid Mechanics, TU Braunschweig*

Gilles Tissot, *Institute PPRIME, Poitiers*

Laurent Cordier, *Institute PPRIME, Poitiers*

Bernd R. Noack, *Institute PPRIME, Poitiers*

9:00 - 9:30 AM

Data Analysis in Lagrangian Investigation of Turbulence

Roman Volk, *Université de Lyon*

9:30 - 10:00 AM

Are Statistical Symmetries Real?

Martin Oberlack, *Darmstadt University of Technology*

10:00 - 10:30 AM

Drag Reduction of a Blunt Body by Unsteady Coanda Blowing and Shear Layer Forcing

Jacques Borée, *Pprime Poitiers*

D. Barros, *Pprime Poitiers*

B. R. Noack, *Pprime Poitiers*

A. Spohn, *Pprime Poitiers*

T. Ruiz, *Centre Technique de Vélizy*

10:30 - 11:00 AM **COFFEE BREAK**

Session #2C- Turbulence and Renewable Energy

Session Chair:

Raul Cal, *Portland State University*

11:00 - 11:30PM

Measuring the Impact of Turbulence in Wind Energy for the Next 25 Years

Carsten Westegaard, *Texas Tech University*

11:30 - 12:00PM

Low-order Reconstruction of the Canonical Wind Turbine Array Boundary Layer

Murat Tutkun, *University of Oslo*

N. Hamilton, *Portland State University*

R. B. Cal, *Portland State University*

12:00 - 12:30PM

Turbulent Wakes of Wind and Hydrokinetic Turbines: Similarity of the Axisymmetric Wake with Rotation and Insight into the Near-wake of Cross Flow Turbines

Martin Wosnik, *University of New Hampshire*

12:30 - 1:00 PM

Big data from Big experiments:

The WindEEE Dome

Horia Hangan, *University of Western Ontario*

1:00 - 2:00 PM **LUNCH**

2:00 - 6:30 PM **BOAT RIDE**

Thursday, April 23

8:55 AM **Welcome: Day #4:**

Luciano Castillo, *Texas Tech University*

Session #1D- Wall-bounded flows

Session Chair:

Paolo Orlandi, *University of Rome, La Sapienza*

9:00 - 9:30 AM

Topology of Rare Events in Low Reynolds Number Wall Turbulence

Sedat Tardu, *LEGI Grenoble*

9:30 - 10:00AM

Heat Transfer in a Turbulent Channel Flow with Roughness on One Wall

Stefano Leonardi, *University of Texas- Dallas*

10:00 - 10:30 AM

Experimental Investigation of the Dissipation Rate in the Near Wall Region

Jean-Marc Foucaut, *University Lille, France*

C. Cuvier, *University Lille, France*

M. Stanislas, *University Lille, France*

W. K. George, *University Lille, France*

10:30 - 11:00 AM **COFFEE BREAK**

Session #2D- Large Data

Session Chair:

Sedat Tardu, *LEGI Grenoble*

11:00 – 11:30AM

Coarse Grained Simulations of Turbulent Material Mixing

Fernando Grinstein, *Los Alamos National Laboratory*

11:30 – 12:00PM

A 2D Domain Decomposition, a Customized Immersed Boundary Method and a Zest of Numerical Dissipation: A Successful Cocktail to Tackle Turbulence on Supercomputers

Sylvain Laizet, *Imperial College*

Eric Lamballais, *University of Poitiers*

Christos Vassilicos, *Imperial College*

12:00 – 12:30PM

Lattice Boltzmann Method for Turbulence: Real-time Simulation and Big Data Processing

Kai H. Luo, *University College London*

N. Delbosc, *University of Leeds*

J. L. Summers, *University of Leeds*

12:30 - 1:30 PM **LUNCH**

Session #3D- Session #1E: Complex & Industrial Flows

Session Chair:

Luminita Danaila, *University of Rouen*

Clara Velte, *DTU*

1:30 – 2:00 PM

Self-tuning Complex Systems and Data-driven Control of Turbulence

Steven L. Brunton

J. Nathan Kutz

Bernd R. Noack

2:00 - 2:30 PM

Interaction of Flexible Filaments with 3D Transition of Cylinder Wakes

Alfredo Pinelli, *City University London*

M. Omidyeganeh, *City University London*

2:30 - 3:00 PM

Challenges for LES of Engineering Flows

Christer Fureby, *The Swedish Defence Research Agency*

3:00 - 3:30 PM

Turbulence and Aerospace Engines

Peter Johansson, *GKN Aerospace*

3:30 – 4:00 PM **COFFEE BREAK**

**Session #4D-
Day 4: Discussion- Large Data:
Opportunities for
Collaborations**

Session Chair:

Luciano Castillo, *Texas Tech University*

4:30- 5:00PM

Dealing with Large Databases

Thomas Hacker, *Purdue University*

Shirley Dyke, *Purdue University*

Luciano Castillo, *Texas Tech University*

5:00 – 5:45PM

DISCUSSION- Large Data

Martin Oberlack, *Darmstadt University of
Technology*

Bernd Noack, *University of Poitiers*

DINNER RESTAURANT

6:00pm – 8:30PM

Luminita Danaila, *University of Rouen*

Friday, April 24

8:50 - 9:00 AM

**Welcome & Major Observations of
Symposium**

Luciano Castillo, *Texas Tech University*

Session #1E- Turbulence

Session Chair:

Mark Glauser, *Syracuse University*

9:00 - 9:30 AM

A 50 Year Retrospective and the Future

William K. George, *Imperial College*

9:30 - 10:00 AM

**Non-classical Decay Regimes in Multi-scale
/Fractal Generated Isotropic Turbulence**

Marcello Meldi, *Institut PPRIME – Université
de Poitiers, France*

Pierre Sagaut, *Laboratoire de Mécanique,
Modélisation & Procédés Propres*

10:00 - 10:30 AM

**Spectral Energy Budget of Stratified
Turbulence**

Stefan Hickel, *TUM*

Sebastian Remmler, *Delft University of
Technology*

10:30 - 11:00 AM **COFFEE BREAK**

**Session #2E- Simulations &
Experiments**

Session Chair:

Charles Tinney, *University of Texas- Austin*

11:00- 11:30 AM

PIV Measurements on Turbulent Vortex Rings

Knud-Erik Meyer, *DTU*

11:30– 12:15PM (Poster)

DNS of Turbulence in Gradual Expansion Pipe

Kamal Selvam, *CNRS and Université du Havre*

**Simultaneous Velocity Field POD Mode
Coupling in Two PIV Planes to Decompose
the Turbulent Round Jet (Poster)**

Azur Hodzic, *DTU*

Clara M. Velte, *DTU*

Knud Erik Meyer, *DTU*

Maja Wänström, *SMHI*

William K. George, *Imperial College*

CLOSING REMARKS

Luminita Danaila, *University of Rouen*

Jean-Paul Bonnet, *University of Poitiers*

12:30 – 1:30PM LUNCH

NOTES

THANK YOU TO OUR SPONSORS





Symposium held at the
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2015