

# On the Correlation Between Large-Scale Structures in the Vicinity of Turbulent/Non-turbulent Interface and Wall Pressure Within the Turbulent Boundary Layer

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Abstract. The present work investigates the relation between large-scale coherent structures in the vicinity of turbulent/non-turbulent interface and corresponding pressure fluctuations within the turbulent boundary layer (TBL) close to the trailing edge of the NACA0012 airfoil. The planar particle image velocimetry (PIV) measurements were conducted to capture the instantaneous velocity fields, with simultaneous wall-pressure fluctuation measurement obtained by miniature transducers. Based on the identifications of high amplitude pressure peaks (HAPPs) in the pressure signal, the corresponding simultaneous measured velocity fields are conditionally averaged, revealing the dominance of high-speed large-scale motions (LSMs). The simultaneously measured pressure fluctuations are conditionally extracted based on the occurrence of low- and high-speed LSMs. Results show that high-speed LSMs induce high-energy positive pressure fluctuations, especially when located upstream of the reference wall pressure transducer. The correlation analysis between various scale velocities acquired by empirical modal decomposition (EMD) and the reference pressure signal is conducted. It is demonstrated that upstream high-speed motions with sweeps accompanied by downstream low-speed motions with ejections are responsible for the positive pressure fluctuations, while the negative pressure fluctuations are attributed to the adverse arrangement. It is also observed that the sourced coherent structures of pressure fluctuations can expand outside the TBL, with significant momentum exchange across the turbulent/non-turbulent interface (TNTI).

Keywords: Turbulent Boundary Layer - Coherent Structures · Wall Pressure Fluctuations - Velocity – Pressure Correlation

#### 1 Introduction

The wall-pressure fluctuations in the turbulent boundary layer (TBL) play a key role in noise generation and structure vibrations (Seongkyu Lee et al. 2021). Especially for a trailing edge turbulent boundary layer, the scattering of wall pressure fluctuation at the

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Measurement Techniques in Heat and Mass Transfer Rem Ivanovich Soloukhin, Naim Hamdia Afgan, 1985
Turbulence and Coherent Structures O. Métais, Marcel Lesieur, 2014-03-14 In the last 25 years one of the most striking advances in Fluid Mecha nics was certainly the discovery of coherent structures in turbulence lab oratory experiments and numerical simulations have shown that most turbulent flows exhibit both spatially organized large scale structures and disorganized motions generally at smaller scales The develop ment of new measurement and visualization techniques have allowed a more precise characterization and investigation of these structures in the laboratory Thanks to the unprecedented increase of computer power and to the development of efficient interactive three dimensional colour graphics computational fluid dynamicists can explore the still myste rious world of turbulence However many problems remain unsolved concerning the origin of these structures their dynamics and their in teraction with the disorganized motions In this

book will be found the latest results of experimentalists theoreticians and numerical modellers interested in these topics. These coherent structures may appear on airplane wings or slender bodies mixing layers jets wakes or boundary layers. In free shear flows and in boundary layers the results presented here highlight the intense three dimensional character of the vortices. The two dimensional large scale eddies are very sensitive to three dimensional perturbations whose amplification leads to the formation of three dimensional coherent vortical structures such as streamwise hairpin or horseshoe vortex filaments. This book focuses on modern aspects of turbulence study Relations between turbulence theory and optimal control theory in mathematics are discussed. This may have important applications with regard to e.g. numerical weather forecasting

Coherent Structures in Turbulent Flows Roi Gurka, Ţekhniyon, Makhon ţekhnologi le-Yiśra'el. Fakulţah le-handasat mekhonot, 2003 On the detection of coherent structures in turbulent flows Joseph M. Kunen, 1984 Characterization of Coherent Structures in Turbulent Flows Alex Liberzon, Ţekhniyon, Makhon ţekhnologi le-Yiśra'el. Fakulţah le-handasat mekhonot, 2003 Study of Coherent Structures in Turbulent Flows Using Proper Orthogonal Decomposition

Maziar Eslami Samani, 2014 Coherent Structures and Control in Wall-bounded Turbulent Flows Marco Atzori, 2021

New Approaches and Concepts in Turbulence T. Dracos, A. Tsinober, 2012-10-11 This book contains the proceedings of a colloquium held in Monte Verit from September 9 13 1991 Special care has been taken to devote adequate space to the scientific discussions which claimed about half of the time available Scientists from all over the world presented their views on the importance of kinematic properties topology and fractal geometry and on the dynamic behaviour of turbulent flows They debated the importance of coherent structures and the possibility to incorporate these in the statistical theory of turbulence as well as their significance for the reduction of the degrees of freedom and the prospective of dynamical systems and chaos approaches to the problem of turbulence Also under discussion was the relevance of these new approaches to the study of the instability and the origin of turbulence and the importance of numerical and physical experiments in improving the understanding of turbulence Coherent Structures and Statistical Mechanics in Two-dimensional Flows Hanna Brands, 1998 Dynamics of Coherent Structures in Turbulent Flow Over a Backwards-facing Step Stephen J. Wilkins, 2019 The Essence of Turbulence as a Physical Phenomenon Arkady Tsinober, 2018-12-17 Now in its second edition this book clearly concisely and comprehensively outlines the essence of turbulence In view of the absence of a theory based on first principles and adequate tools to handle the problem the essence of turbulence i e what turbulence really is from a fundamental point of view is understood empirically through observations from nature laboratories and direct numerical simulations rather than explained by means of conventional formalistic aspects models etc resulting in pertinent issues being described at a highly theoretical level in spite of the mentioned lack of theory As such the book highlights and critically reexamines fundamental issues especially those of paradigmatic nature related to conceptual and problematic aspects key misconceptions and unresolved matters and discusses why the problem is so difficult As in the previous edition

the focus on fundamental issues is also a consequence of the view that without corresponding advances in fundamental aspects there is little chance of progress in any applications More generally there is a desperate need for physical fundamentals of a great variety of processes in nature and technology in which turbulence plays a central role Turbulence is omnipresent throughout the natural sciences and technology but despite the vast sea of information available the book retains its brevity without oversimplifications making it of interest to a broad audience \*\*Coherent Structures and \*\*Transient Amplification Mechanisms in Transitional and Turbulent Flows Yuxin Jiao, 2022 \*\*Turbulence in Open Channel Flows\*\* Hiroji Nakagawa, Iehisa Nezu, 2017-10-02 A review of open channel turbulence focusing especially on certain features stemming from the presence of the free surface and the bed of a river Part one presents the statistical theory of turbulence Part two addresses the coherent structures in open channel flows and boundary layers \*\*1969, \[ \] \[ \] \[ \] \] Statistical Representations of Coherent Structures in Turbulent Flow Fields David Hugh Chambers, 1987

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#### Table of Contents Nice Book Coherent Structures Parietal Turbulent Flows

- 1. Understanding the eBook Nice Book Coherent Structures Parietal Turbulent Flows
  - The Rise of Digital Reading Nice Book Coherent Structures Parietal Turbulent Flows
  - Advantages of eBooks Over Traditional Books
- 2. Identifying Nice Book Coherent Structures Parietal Turbulent Flows
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
- 3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Nice Book Coherent Structures Parietal Turbulent Flows
  - User-Friendly Interface
- 4. Exploring eBook Recommendations from Nice Book Coherent Structures Parietal Turbulent Flows
  - Personalized Recommendations
  - Nice Book Coherent Structures Parietal Turbulent Flows User Reviews and Ratings
  - Nice Book Coherent Structures Parietal Turbulent Flows and Bestseller Lists
- 5. Accessing Nice Book Coherent Structures Parietal Turbulent Flows Free and Paid eBooks

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- Nice Book Coherent Structures Parietal Turbulent Flows eBook Subscription Services
- Nice Book Coherent Structures Parietal Turbulent Flows Budget-Friendly Options
- 6. Navigating Nice Book Coherent Structures Parietal Turbulent Flows eBook Formats
  - o ePub, PDF, MOBI, and More
  - Nice Book Coherent Structures Parietal Turbulent Flows Compatibility with Devices
  - Nice Book Coherent Structures Parietal Turbulent Flows Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Nice Book Coherent Structures Parietal Turbulent Flows
  - Highlighting and Note-Taking Nice Book Coherent Structures Parietal Turbulent Flows
  - Interactive Elements Nice Book Coherent Structures Parietal Turbulent Flows
- 8. Staying Engaged with Nice Book Coherent Structures Parietal Turbulent Flows
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Nice Book Coherent Structures Parietal Turbulent Flows
- 9. Balancing eBooks and Physical Books Nice Book Coherent Structures Parietal Turbulent Flows
  - Benefits of a Digital Library
  - o Creating a Diverse Reading Collection Nice Book Coherent Structures Parietal Turbulent Flows
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Nice Book Coherent Structures Parietal Turbulent Flows
  - Setting Reading Goals Nice Book Coherent Structures Parietal Turbulent Flows
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Nice Book Coherent Structures Parietal Turbulent Flows
  - Fact-Checking eBook Content of Nice Book Coherent Structures Parietal Turbulent Flows
  - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development

- Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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