

FLUID MECHANICS AND ITS APPLICATIONS

Yuri P. Golovachov

# Numerical Simulation of Viscous Shock Layer Flows



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# Numerical Simulation Of Viscous Shock Layer Flows

**Philipp Schlatter, Dan S. Henningson**



## **Numerical Simulation Of Viscous Shock Layer Flows:**

Numerical Simulation of Viscous Shock Layer Flows Y.P. Golovachov, 2013-03-09 The book is concerned with mathematical modelling of supersonic and hyper sonic flows about bodies Permanent interest in this topic is stimulated first of all by aviation and aerospace engineering The designing of aircraft and space vehicles requires a more precise prediction of the aerodynamic and heat transfer characteristics Together with broadening of the flight condition range this makes it necessary to take into account a number of gas dynamic and physical effects caused by rarefaction viscous inviscid interaction separation various physical and chemical processes induced by gas heating in the intensive bow shock wave The flow field around a body moving at supersonic speed can be divided into three parts namely shock layer near wake including base flow and far wake The shock layer flow is bounded by the bow shock wave and the front and lateral parts of the body surface A conventional approach to calculation of shock layer flows consists in a successive solution of the inviscid gas and boundary layer equations When the afore mentioned effects become important implementation of these models meets difficulties or even becomes impossible In this case one has to use a more general approach based on the viscous shock layer concept

**Asymptotic Modelling of Fluid Flow Phenomena** Radyadour Kh. Zeytounian, 2006-04-10 for the fluctuations around the means but rather fluctuations and appearing in the following incompressible system of equations on any wall at initial time and are assumed known This contribution arose from discussion with J P Guiraud on attempts to push forward our last co signed paper 1986 and the main idea is to put a stochastic structure on fluctuations and to identify the large eddies with a part of the probability space The Reynolds stresses are derived from a kind of Monte Carlo process on equations for fluctuations Those are themselves modelled against a technique using the Guiraud and Zeytounian 1986 The scheme consists in a set of like equations considered as random because they mimic the large eddy fluctuations The Reynolds stresses are got from stochastic averaging over a family of their solutions Asymptotics underlies the scheme but in a rather loose hidden way We explain this in relation with homogenization localization processes described within the 3 4 of Chapter 3 Ofcourse the mathematical well posedness of the scheme is not known and the numerics would be formidable Whether this attempt will inspire researchers in the field of highly complex turbulent flows is not foreseeable and we have hope that the idea will prove useful

**Hydrodynamic and Magnetohydrodynamic Turbulent Flows** A. Yoshizawa, 2013-03-14 Turbulence modeling encounters mixed evaluation concerning its importance In engineering flow the Reynolds number is often very high and the direct numerical simulation DNS based on the resolution of all spatial scales in a flow is beyond the capability of a computer available at present and in the foreseeable near future The spatial scale of energetic parts of a turbulent flow is much larger than the energy dissipative counterpart and they have large influence on the transport processes of momentum heat matters etc The primary subject of turbulence modeling is the proper estimate of these transport processes on the basis of a bold approximation to the energy dissipation one In the engineering community the turbulence modeling is highly evaluated as a

mathematical tool indispensable for the analysis of real world turbulent flow In the physics community attention is paid to the study of small scale components of turbulent flow linked with the energy dissipation process and much less interest is shown in the foregoing transport processes in real world flow This research tendency is closely related to the general belief that universal properties of turbulence can be found in small scale phenomena Such a study has really contributed much to the construction of statistical theoretical approaches to turbulence The estrangement between the physics community and the turbulence modeling is further enhanced by the fact that the latter is founded on a weak theoretical basis compared with the study of small scale turbulence

Direct Methods for Solving the Boltzmann Equation and Study of Nonequilibrium Flows V.V. Aristov, 2012-12-06 This book is concerned with the methods of solving the nonlinear Boltzmann equation and of investigating its possibilities for describing some aerodynamic and physical problems This monograph is a sequel to the book *Numerical direct solutions of the kinetic Boltzmann equation* in Russian which was written with F G Tcheremissine and published by the Computing Center of the Russian Academy of Sciences some years ago The main purposes of these two books are almost similar namely the study of nonequilibrium gas flows on the basis of direct integration of the kinetic equations Nevertheless there are some new aspects in the way this topic is treated in the present monograph In particular attention is paid to the advantages of the Boltzmann equation as a tool for considering nonequilibrium nonlinear processes New fields of application of the Boltzmann equation are also described Solutions of some problems are obtained with higher accuracy Numerical procedures such as parallel computing are investigated for the first time The structure and the contents of the present book have some common features with the monograph mentioned above although there are new issues concerning the mathematical apparatus developed so that the Boltzmann equation can be applied for new physical problems Because of this some chapters have been rewritten and checked again and some new chapters have been added

*IUTAM Symposium on Combustion in Supersonic Flows* M. Champion, B. Deshaies, 2012-12-06 Proceedings of the IUTAM Symposium held in Poitiers France 26 October 1995

Turbulent Flow Computation D. Drikakis, Bernard Geurts, 2006-04-11 In various branches of fluid mechanics our understanding is inhibited by the presence of turbulence Although many experimental and theoretical studies have significantly helped to increase our physical understanding a comprehensive and predictive theory of turbulent flows has not yet been established Therefore the prediction of turbulent flow relies heavily on simulation strategies The development of reliable methods for turbulent flow computation will have a significant impact on a variety of technological advancements These range from aircraft and car design to turbomachinery combustors and process engineering Moreover simulation approaches are important in materials sign prediction of biologically relevant flows and also significantly contribute to the understanding of environmental processes including weather and climate forecasting The material that is compiled in this book presents a coherent account of contemporary computational approaches for turbulent flows It aims to provide the reader with information about the current state of the art as well as to stimulate directions for

future research and development The book puts particular emphasis on computational methods for incompressible and compressible turbulent flows as well as on methods for analysing and quantifying numerical errors in turbulent flow computations In addition it presents turbulence modelling approaches in the context of large eddy simulation and unfolds the challenges in the field of simulations for multiphase flows and computational fluid dynamics CFD of engineering flows in complex geometries Apart from reviewing main research developments new material is also included in many of the chapters

**IUTAM Symposium on Nonlinear Waves in Multi-Phase Flow** H.-C. Chang, 2013-06-29 The active field of multiphase flow has undergone fundamental changes in the last decade Many salient complex interfacial dynamics of such flows are now understood at a basic level with precise mathematical and quantitative characterization This is quite a departure from the traditional empirical approach At an IUTAM Symposium at Notre Dame in 1999 some of the leading researchers in the field gathered to review the progress thus far and to contemplate future directions Their reports are summarized in this Proceedings Topics covered include solitary wave dynamics on viscous film flows sheet formation and drop entrainment in stratified flow wetting and dewetting dynamics self similar drop formation dynamics waves in bubbly and suspension flow and bubble dynamics It is a unique and essential reference for applied mathematicians physicists research engineers and graduate students to keep abreast of the latest theoretical and numerical developments that promise to transform multiphase flow research *IUTAM Symposium on Mechanics of Passive and Active Flow Control* G.E.A. Meier, P.R.

Viswanath, 2012-12-06 The call for papers for the rUTAM Symposium on Mechanics of Passive and Active Flow Control brought an overwhelming response of applications for contributions Finally 12 invited lectures 48 papers and 23 posters were selected by the Scientific Committee to be presented in the conference 58 papers are published in this volume Due to the limited number of pages available poster presentations could not be considered for publication The editors would like to thank all the members of the Scientific Committee for their very valuable assistance The papers presented at the rUTAM Symposium were classified under three groups devoted to Passive Control Methods Active Control Methods and Control Concepts This was done to contrast at first between the passive techniques where the control power is mainly supplied by the flow itself and the active techniques where the power is provided by external sources the third group was devoted to control concepts for presenting methods of control theory and new techniques of flow control *Scientific and Technical Aerospace Reports*, **Applied mechanics reviews**, 1948 **Super- and Hypersonic Aerodynamics and Heat Transfer** V.Z.

Parton, 2018-03-29 Recent government and commercial efforts to develop orbital and suborbital passenger and transport aircraft have resulted in a burgeoning of new research The articles in this book translated from Russian were contributed by the world's leading authorities on supersonic and hypersonic flows and heat transfer This superb book addresses the physics and engineering aspects of ultra high speed aerodynamic problems Thorough coverage is given to an array of specific problem solving equations Super and Hypersonic Aerodynamics and Heat Transfer will be essential reading for all

aeronautical engineers mechanical engineers mathematicians and physicists involved in this exciting field of research

*Modeling in Fluid Mechanics* Igor Gaissinski, Vladimir Rovenski, 2018-06-13 This volume is dedicated to modeling in fluid mechanics and is divided into four chapters which contain a significant number of useful exercises with solutions The authors provide relatively complete references on relevant topics in the bibliography at the end of each chapter

**Seventh IUTAM Symposium on Laminar-Turbulent Transition** Philipp Schlatter, Dan S. Henningson, 2010-03-11 The origins of turbulent flow and the transition from laminar to turbulent flow are the most important unsolved problems of fluid mechanics and aerodynamics sides being a fundamental question of fluid mechanics there are numerous applications relying on information regarding transition location and the details of the subsequent turbulent flow For example the control of transition to turbulence is especially important in 1 skin friction reduction of energy efficient aircraft 2 the performance of heat exchangers and diffusers 3 propulsion requirements for personic aircraft and 4 separation control While considerable progress has been made in the science of laminar to turbulent transition over the last 30 years the continuing increase in computer power as well as new theoretical developments are now revolutionizing the area It is now starting to be possible to move from simple 1D eigenvalue problems in canonical flows to global modes in complex flows all accompanied by accurate large scale direct numerical simulations DNS Here novel experimental techniques such as modern particle image velocimetry PIV also have an important role Theoretically the influence of non normality on the stability and transition is gaining importance in particular for complex flows At the same time the enigma of transition in the oldest flow investigated Reynolds pipe flow transition experiment is regaining attention Ideas from dynamical systems together with DNS and experiments are here giving us new insights

**IUTAM Symposium on Computational Approaches to Multiphase Flow** S. Balachandar, A. Prosperetti, 2007-01-28 The book provides a broad overview of the full spectrum of state of the art computational activities in multiphase flow as presented by top practitioners in the field It starts with well established approaches and builds up to newer methods These methods are illustrated with applications to a broad spectrum of problems involving particle dispersion and deposition turbulence modulation environmental flows fluidized beds bubbly flows and many others

*IUTAM Symposium on Nonlinear Instability and Transition in Three-Dimensional Boundary Layers* Peter W. Duck, Philip Hall, 2012-12-06 Most fluid flows of practical importance are fully three dimensional so the non linear instability properties of three dimensional flows are of particular interest In some cases the three dimensionality may have been caused by a finite amplitude disturbance whilst more usually the unperturbed state is three dimensional Practical applications where transition is thought to be associated with non linearity in a three dimensional flow arise for example in aerodynamics swept wings engine nacelles etc turbines and aortic blood flow Here inviscid cross flow disturbances as well as Tollmien Schlichting and Görtler vortices can all occur simultaneously and their mutual non linear behaviour must be understood if transition is to be predicted The non linear interactions are so complex that usually fully numerical or combined asymptotic numerical methods must be used

Moreover in view of the complexity of the instability processes there is also a growing need for detailed and accurate experimental information. Carefully conducted tests allow us to identify those elements of a particular problem which are dominant. This assists in both the formulation of a relevant theoretical problem and the subsequent physical validation of predictions. It should be noted that the demands made upon the skills of the experimentalist are high and that the tests can be extremely sophisticated, often making use of the latest developments in flow diagnostic techniques, automated high speed data gathering, data analysis, fast processing and presentation.

#### **IUTAM Symposium on Free Surface Flows** A.C.

King, Y.D. Shikhmurzaev, 2012-12-06 Free surface flows arise in the natural world, physical and biological sciences and in some areas of modern technology and engineering. Examples include the breaking of sea waves on a harbour wall, the transport of sloshing fluids in partly filled containers and the design of micronozzles for high speed ink jet printing. Apart from the intrinsic mathematical challenge in describing and solving the governing equations, there are usually important environmental safety and engineering features which need to be analysed and controlled. A rich variety of techniques has been developed over the past two decades to facilitate this analysis: singular perturbations, dynamical systems and the development of sophisticated numerical codes. The extreme and sometimes violent nature of some free surface flows taxes these methods to the limit. The work presented at the symposium addressed these limits and can be loosely classified into four areas: i) Axisymmetric free surface flows. There are a variety of problems in the printing glass, fertiliser and fine chemical industries in which threads of fluid are made and controlled. Presentations were made in the areas of pinch off for inviscid and viscous threads of fluid, recoil effects after droplet formation and the control of instability by forced vibration. ii) Dynamic wetting. The motion of three phase contact lines which are formed at the junction between two fluids and a solid plays an important role in fluid mechanics.

#### **AIAA Journal** American Institute of Aeronautics and Astronautics, 2004

IUTAM Symposium on Reynolds Number Scaling in Turbulent Flow Alexander J. Smits, 2012-12-06 This volume presents selected papers from the IUTAM Symposium on Reynolds Number Scaling in Turbulent Flow convened in Princeton, NJ, USA, September 11-13, 2002. The behavior of turbulence at high Reynolds number is interesting from a fundamental point of view in that most theories of turbulence make very specific predictions in the limit of infinite Reynolds number. From a more practical point of view, there exist many applications that involve turbulent flow where the Reynolds numbers are extremely large. For example, large vehicles such as submarines and commercial transports operate at Reynolds numbers based on length of the order of  $10^8$  and industrial pipe flows cover a very wide range of Reynolds numbers up to  $10^7$ . Many very important applications of high Reynolds number flow pertain to atmospheric and other geophysical flows where extremely high Reynolds numbers are the rule rather than the exception and the understanding of climate changes and the prediction of destructive weather effects hinges to some extent on our appreciation of high Reynolds number turbulence behavior. The important effects of Reynolds number on turbulence have received a great deal of recent attention. The objective of the

Symposium was to bring together many of the world's experts in this area to appraise the new experimental results discuss new scaling laws and turbulence models and to enhance our mutual understanding of turbulence **Current**

**Mathematical Problems of Mechanics and Their Applications** A. А Бармин, Leonid Ivanovich Sedov, 1991 This volume contains selected reports delivered at the international conference on Modern mathematical problems of mechanics and their applications which took place in Moscow in 1987 on the occasion of the 80th birthday of Academician L I Sedov The papers are devoted to a wide range of problems of modern mechanics including general relativity and gravitation construction and investigation of models of continuum mechanics gas dynamics with due regard to physical and chemical processes hydromechanics hydrodynamic stability and turbulence magnetohydrodynamics electrodynamics and nonlinear problems of mechanics of deformable solid body Containing results by well known specialists this book is of interest to specialists in mechanics and mathematics *The CRC Handbook of Mechanical Engineering* D. Yogi Goswami, 2004-09-29 The second edition of this standard setting handbook provides and all encompassing reference for the practicing engineer in industry government and academia with relevant background and up to date information on the most important topics of modern mechanical engineering These topics include modern manufacturing and design robotics computer engineering environmental engineering economics patent law and communication information systems The final chapter and appendix provide information regarding physical properties and mathematical and computational methods New topics include nanotechnology MEMS electronic packaging global climate change electric and hybrid vehicles and bioengineering



The Enigmatic Realm of **Numerical Simulation Of Viscous Shock Layer Flows**: Unleashing the Language is Inner Magic

In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing lacking extraordinary. Within the captivating pages of **Numerical Simulation Of Viscous Shock Layer Flows** a literary masterpiece penned by way of a renowned author, readers embark on a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting impact on the hearts and minds of those who partake in its reading experience.

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