Editors:
Prof. Siavash H. Sohrab, Northwestern University, USA
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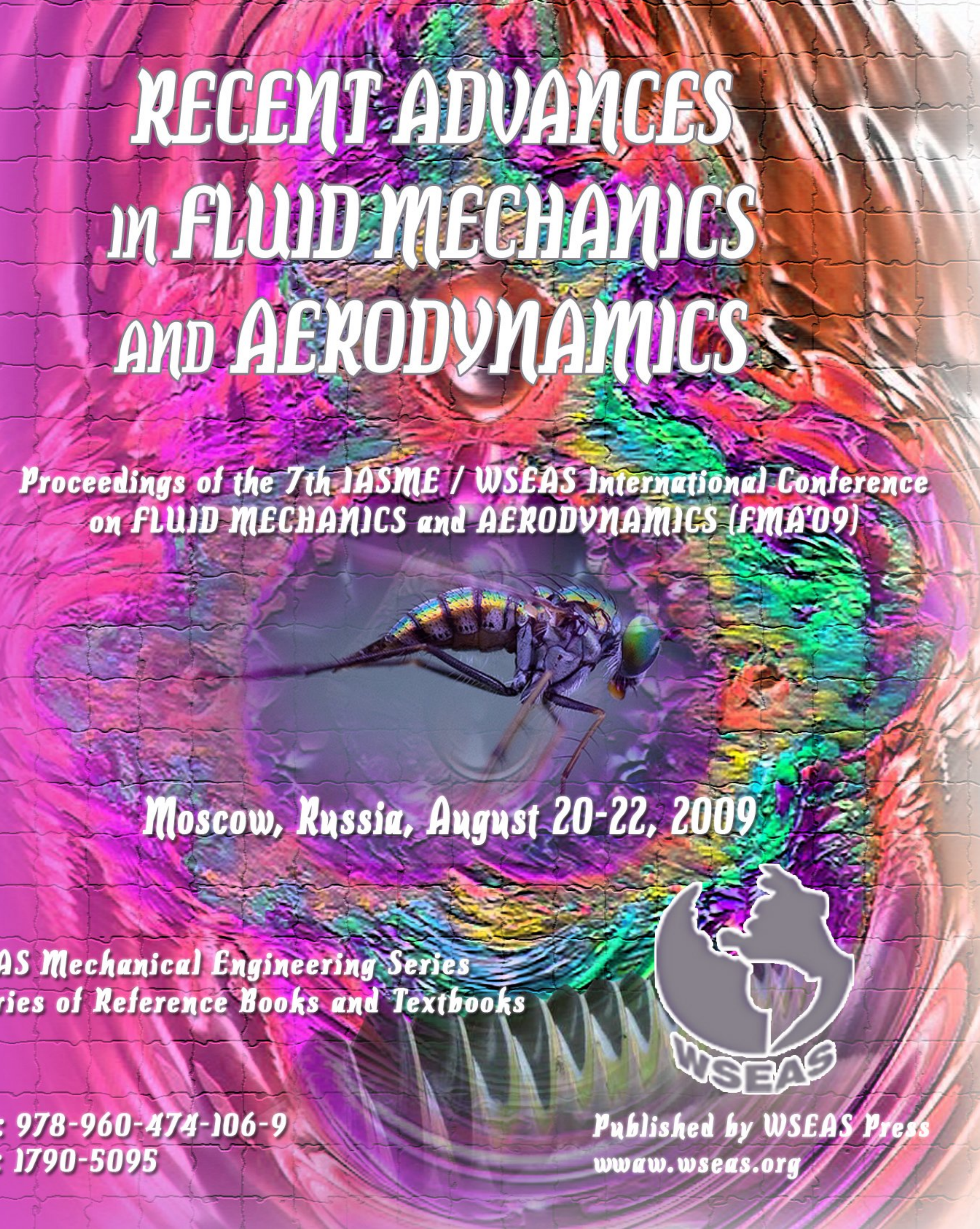
Dr. Nikolai Kobasko, IQ Technologies Inc, USA

RECENT ADVANCES IN FLUID MECHANICS AND AERODYNAMICS



Proceedings of the 7th IASME / WSEAS International Conference
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Preface

This year the 7th IASME / WSEAS International Conference on FLUID MECHANICS and AERODYNAMICS (FMA '09) was held in Moscow, Russia, in August 20-22, 2009. The Conference remains faithful to its original idea of providing a platform to discuss mathematical modeling in fluid mechanics, simulation in fluid mechanics, multiphase flow, boundary layer flow, fluid structure interaction, hydrotechnology, hydraulic and thermal turbomachines, hydrodynamics, adiabatic flow, non steady flow, wave modeling etc. with participants from all over the world, both from academia and from industry.

Its success is reflected in the papers received, with participants coming from several countries, allowing a real multinational multicultural exchange of experiences and ideas.

The accepted papers of this conference are published in this Book that will be indexed by ISI. Please, check it: www.worldses.org/indexes as well as in the CD-ROM Proceedings. They will be also available in the E-Library of the WSEAS. The best papers will be also promoted in many Journals for further evaluation.

A Conference such as this can only succeed as a team effort, so the Editors want to thank the International Scientific Committee and the Reviewers for their excellent work in reviewing the papers as well as their invaluable input and advice.

The Editors

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Plenary Lecture 1

Modeling and Simulation of Inhomogeneous Stratified Turbulent Flows

Professor Albert F. Kurbatsky
Khristianovich Institute of Theoretical and Applied Mechanics
Russian Academy of Sciences, Siberian Branch and
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Russia, Novosibirsk
Email: kurbat@nsu.ru

Abstract: The modeling and simulation of the planetary boundary layer over land is a persistent, problematic feature in weather, climate, pollutant dispersion, and air quality topics. Planetary boundary layers are usually classified into three types: neutral, convective, and stable, based on its stability: buoyancy effects and the dominant mechanism of turbulence generation. Stable boundary layer turbulence has inevitable difficulties in numerical simulations (arising from small scales of motion due to stratification) and to the intrinsic complexity in its dynamics, e.g., occurrences of intermittency, Kelvin-Helmholtz instability, gravity waves, low-level jets, meandering motions, etc. Therefore is not surprising that today there is a general consensus among researches that our understanding of stable boundary layer (especially the very stable regime) is quite poor and even small future advances justify more work. To improve parameterization of stable boundary layer turbulence in this study is used so-called RANS approach for obtaining, nonlocal on-being, anisotropic expressions for turbulent fluxes of momentum and scalar. Numerical modeling of boundary layer evolution in all range from the convective to a stable state shows that such improved parameterization of turbulence allows to obtain for very stable regime (Richardson's number more than 0.25) that the turbulent Prandtl number stability dependent from the gradient Richardson's number (the result fixed by the laboratory measurements) that allows momentum to be transported by the internal waves, while heat diffusion is impeded by the stratification. This improvement alleviates the problem of over prediction of heat diffusion under stable conditions, which is a characteristic of conventional boundary-layer schemes, such as the Medium Range Forecast (MRF) employed in the mesoscale models such as the Penn State/NCAR Mesoscale Model (MM5).

Brief Biography of the Speaker: The modeling and simulation of the planetary boundary layer over land is a persistent, problematic feature in weather, climate, pollutant dispersion, and air quality topics. Planetary boundary layers are usually classified into three types: neutral, convective, and stable, based on its stability: buoyancy effects and the dominant mechanism of turbulence generation. Stable boundary layer turbulence has inevitable difficulties in numerical simulations (arising from small scales of motion due to stratification) and to the intrinsic complexity in its dynamics, e.g., occurrences of intermittency, Kelvin-Helmholtz instability, gravity waves, low-level jets, meandering motions, etc. Therefore is not surprising that today there is a general consensus among researches that our understanding of stable boundary layer (especially the very stable regime) is quite poor and even small future advances justify more work. To improve parameterization of stable boundary layer turbulence in this study is used so-called RANS approach for obtaining, nonlocal on-being, anisotropic expressions for turbulent fluxes of momentum and scalar. Numerical modeling of boundary layer evolution in all range from the convective to a stable state shows that such improved parameterization of turbulence allows to obtain for very stable regime (Richardson's number more than 0.25) that the turbulent Prandtl number stability dependent from the gradient Richardson's number (the result fixed by the laboratory measurements) that allows momentum to be transported by the internal waves, while heat diffusion is impeded by the stratification. This improvement alleviates the problem of over prediction of heat diffusion under stable conditions, which is a characteristic of conventional boundary-layer schemes, such as the Medium Range Forecast (MRF) Professor Albert Kurbatsky received Master Sc degree in Physics from the Novosibirsk State University, Russia, in 1963. He obtained Ph.D. degree and then DSc (Phys. and Math.) degree from the Institute of Thermophysics of Russian Academy of Sciences, Siberian Branch, Russia, Novosibirsk, in 1975 and 1985, respectively. He is a Professor at the Department of Physics at the Novosibirsk State University, Russia, Novosibirsk and he is the Principal Scientific Researcher at the Khristianivich Institute of Theoretical and Applied Mechanics of Russian Academy of Sciences, Siberian Branch, Russia, Novosibirsk. Prof. Kurbatsky’s research work & interest include studies in modeling and simulation of complex turbulent flows in environment with application to the planetary boundary layer, in particular. He is author of over 160 publications mostly published in rigorously referred journals. He is author of two monographies on the turbulence modeling.employed in the mesoscale models such as the Penn State/NCAR Mesoscale Model (MM5).

Plenary Lecture 2

Role of Flow Non-Parallelism in the Excitation and Amplification of Disturbances in a Supersonic Boundary Layer

Professor Sergey A. Gaponov
Khristianovich Institute of Theoretical and Applied Mechanics (ITAM)
SB RAS, 630090, Novosibirsk, RUSSIA
E-mail: gaponov@itam.nsc.ru

Abstract: The receptivity of external waves and instability of a supersonic boundary layer is considered. It is well known that unstable hydrodynamic waves can be excited by external waves in both subsonic and supersonic flows. It has also been established that for linear interactions of monochromatic waves with laminar flow the excitation is possible only in nonparallel streams. The distinguishing characteristic in the generation mechanism of the unstable waves by sound for subsonic and supersonic flows is as follows: For fixed frequency and low velocities, the parameter values of sound waves differ considerably from those of unstable waves. The effective generation of Tollmien-Schlichting (T.-S.) waves takes place only in the presence of a strong non-homogeneity, e.g., roughness or the leading edge of the model. However in the case of supersonic flow both wave parameters are similar. This fact has two consequences. First of all the sound phase velocity can coincide with the flow velocity in the boundary layer, and a critical layer appears which leads to strong oscillations in the boundary layer. Second because sound and T.-S. waves have similar characteristics their parameters become indistinguishable in nonparallel flow. Thus effective transmission of oscillatory energy from sound waves into eigen-oscillations takes place. In this paper both the interaction of external waves with parallel flow and the possible excitation of eigen-oscillations in nonparallel flow are considered in linear approach.

The second way of eigen-oscillations excitation is connected with the non-linear disturbances interaction. In particular two problems are discussed. In one of them influence of acoustic disturbances wind tunnel on generation of amplified waves in the modal boundary layer is studied. In the second example Tollmien-Schlichting waves generation by another frequency disturbances is investigated.

This work has been financially supported by the RFBR (Grant No. 08-01-00038a)

Brief Biography of the Speaker: Field of research: Fluid dynamics, laminar- turbulent transition in wall-bounded shear layers.

Surname: Gaponov First name: Sergey Date of birth: August 20, 1940

Affiliation: Laboratory wave processes in supersonic viscous flows, Institute of Theoretical and Applied Mechanics of Siberian Branch of Russian Academy of Science (ITAM SB RAS); Professor at the Department of Theoretical Mechanics, Novosibirsk State University of Architecture and Civil Engineering (NSUACE).

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Education: Graduated from Physics Department of Novosibirsk State University (NSU), 1964.

Brief description of professional career (including the title of the dissertation work, the year and the Institution where it has been defended):

1. Junior and Senior Scientific Researcher, Head of Laboratory of the Institute of Theoretical and Applied Mechanics SB RAS, January 1965 – till now.
2. Professor at the Department of Theoretical Mechanics, Novosibirsk State University of Architecture and Civil Engineering (NSUACE), 1992-till now.

Ph.D. Thesis: "Stability of the Incompressible Boundary Layer on a Permeable Surface", 1971, Institute of Theoretical and Applied Mechanics of Siberian Branch of Russian Academy of Science (ITAM SB RAS).

Degree of Doctor (Physics and Mathematics): «Development of disturbances in a supersonic boundary layer», 1987, Moscow Physical-Technical Institute.

Other fields: Member of Council on Defence of doctoral Thesis's at Institute of Theoretical and Applied Mechanics, Member of Russian National Committee on Theoretical and Applied Mechanics, Prize-Winner of Professor Joukovski

List of recent grants for fundamental research: Grant of International Science and Technology Center: ISTC-128-96 (1996-1999, investigator). Grants of Russian Foundation for Basic Research (1994-95, 1996-98, 1999-01, 2002-04, 2005-07, 2008-10, team leader.)

Publications: Number of communications to scientific meetings exceed hundred. Number of papers in refereed journals is more than130. Two books were published.

Plenary Lecture 3

Application of Simulation Methods Considering the Interaction between Fluid and Structure

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University of Duisburg-Essen
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Abstract: Many processes in nature and technology can be described only by using laws and equations from different physical disciplines. Such examples, for which the arising sub-problems cannot be solved independently, are called multi-physics applications. A very important class of these multi-physics problems are the fluid-structure-interactions (FSI), which are characterized by the fact, that the flow around a body has a strong impact on the structure and/or on the movement of the body and the modification of the structure or the position of the body or a component of the body due to the flow has an influence on the flow which is not negligible. The two disciplines which are involved in this kind of multi-physics problems are the fluid dynamics and the structure dynamics which both can be described by the relations of continuum mechanics.

Examples of FSI exist in many fields of the natural sciences and the technology. Solutions for the mathematical description of fluid structure interactions can be obtained only by numerical simulations, which still today are a big challenge of scientific computation.

In this contribution initially the fundamental relations for the calculation of the flow behavior and of the structure dynamics will be presented and approaches for numerical solutions of coupled FSI-systems will be pointed out. Afterwards different kinds of coupling methods for the two disciplines and possible methods of partitioning of the numerical simulations are described in detail and evaluated regarding the dependence of the two disciplines from each other. A detailed discussion of solutions for several FSI-examples together with a comparison to experimental results brings this contribution to conclusion.

Brief Biography of the Speaker: Prof. Dr.-Ing. Benra graduated with a diploma degree in Mechanical Engineering at University of Duisburg in 1979. Afterwards he was working as a research assistant at the University of Duisburg and he obtained his doctor degree in Mechanical Engineering in the field of Turbomachinery in 1986. From 1986 to 1989 he was chief of the department for design and development of radial compressors at Mannesmann Demag Company and from 1989 to 1993 he was chief of department for research and development of centrifugal pumps at company Pleiger. Since 1993 he is full Professor for Mechanical Engineering at University of Duisburg-Essen in the field of Turbomachinery and since 2002 he is the head of the Chair for Turbomachinery at University of Duisburg-Essen, Germany. His area of expertise in teaching are: Thermofluid Engineering and Energy Conversion in all kinds of Turbomachines. His current research topics are: Numerical and experimental investigation of time-variant flow in Turbomachines (rotor/stator interaction, fluid/structure interaction, unsteady flow in all kinds of cavities, flow along rough or structured surfaces).

Plenary Lecture 4

The Smoothed Particle Hydrodynamics Method in Computational Fluid Dynamics

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Abstract: Mesh-free methods are gaining in popularity since they are both computationally and numerically efficient, as well as easy to implement and use even in complex problems difficult for traditional grid-based methods. In particle methods a continuous field is represented by sum of weighting functions centered on particles, and the physical properties of the medium are smoothed over some physical length.

The Smoothed Particle Hydrodynamics (SPH) method was originally developed in 1977 for the simulation of stars and asteroids movement in astrophysics, by Bob Gingold and Joe Monaghan, and independently by Leon Lucy. It is a powerful mesh-free particle method, which employs a representative number of discrete particles that span a dynamic mesh used to discretize and solve the continuum equations. A smoothing kernel function is introduced to sum up an approximate value of the field functions from the surrounding particles.

Since its inception, the method has been applied for the simulation of many problems in different areas, including solid, soft and granular materials, and fluid flows. Important industrial applications range from medical training, machinery and vehicle simulators, to special effects for movies and electronic games. To some researchers it might constitute the next generation simulator to replace finite element method and affect strongly the computational field.

SPH method is now commonly used in computational fluid dynamics (CFD) and appears to be promising for the reproduction of very complex and even extreme flow conditions. The fluid flow equations are replaced by particle motion equations and the particles move with the fluid, approximating the continuous flow field. Starting from general dynamic fluid flows, SPH has been used to simulate floating bodies, breaking waves, fluid-structure interaction, shock wave phenomena, explosions etc., and appears to be ideal for unsteady or transient multi-phase flows with moving boundaries and interfaces.

However, there are several points that need further development and certain problems that have to be addressed, like the numerical instabilities under some conditions, the reduced accuracy of the computed pressure field, the application of solid boundary conditions, and the turbulence modelling in complex flows. Moreover, the large number of particles required in 3D simulations entails large number of interactions thus increasing computational demands. For specific applications SPH can be more computationally expensive than the grid-based Navier-Stokes solvers.

The presentation contains the fundamentals of SPH theory, a brief review of recent applications in fluid dynamic problems, and some current research directions for further development.

Brief Biography of the Speaker: John Anagnostopoulos is assistant professor in the School of Mechanical Engineering at the National Technical University of Athens (NTUA), Greece. He received his BS in Mechanical Engineering (1985), and his Ph.D. in Computational Fluid Mechanics (1991) from the NTUA. He worked for several years as principal researcher in various research projects and as R&T consultant. He specialized in the numerical modelling of the flow field and flow mechanisms in various industrial and physical processes, including pulverized coal combustion, fouling, coal grinding, electrostatic precipitation, atmospheric flows and pollutant dispersion, pollutant formation and photochemical kinetics, pulsating flows, steel continuous casting, metal thermal spraying, mechanical erosion wear, centrifugal pumps and pumping installations, impulse hydro turbines.

He has developed several computer codes: COal Combustion Algorithm (COCA), Modeling of Atmospheric Pollution (MAP), COal Grinding Algorithm (COGA), Simulation of ELectrostatic Filters (SELF), FLow Automated Solver (FLAS), Fast Lagrangian Solver (FLS), Hybrid Power Systems Operation Simulator (HYPSOS), and he has been involved in feasibility studies for various industrial innovations.

His current interests include the flow analysis and hydrodynamic design optimization in hydraulic turbomachinery using Eulerian and Lagrangian methods, as well as the optimal sizing and design of hydroelectric, pumped-storage, and hybrid power plants.