



*Editors: Myriam Lazard, Andris Buikis, Yuriy S. Shmaliy, Roberto Revetria,
Nikos Mastorakis, Olga Martin, Gabriella Bognar, Siavash H. Sohrab,
Daniel N. Riahi, Gilbert-Rainer Gillich*

Recent Advances in Fluid Mechanics and Heat & Mass Transfer

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- ^ Proceedings of the 9th IASME / WSEAS International Conference on
Fluid Mechanics & Aerodynamics (FMA '11)*
- ^ Proceedings of the 9th IASME / WSEAS International Conference on
Heat Transfer, Thermal Engineering and Environment (HTE '11)*



Florence, Italy, August 23-25, 2011

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Editors:

Prof. Myriam Lazard, INSTITUT PPRIME, Universite de Poitiers, France
Prof. Andris Buikis, University of Latvia, Latvia
Prof. Yuriy S. Shmaliy, Guanajuato University, Mexico
Prof. Roberto Revetria, University of Genoa, Italy
Prof. Nikos Mastorakis, Technical University of Sofia, Bulgaria
Prof. Olga Martin, University "Politehnica" of Bucharest, Romania
Prof. Gabriella Bognar, University of Miskolc, Hungary
Prof. Siavash H. Sohrab, Northwestern University, USA
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Preface

This year the 9th IASME / WSEAS International Conference on FLUID MECHANICS & AERODYNAMICS (FMA '11) and the 9th IASME / WSEAS International Conference on HEAT TRANSFER, THERMAL ENGINEERING and ENVIRONMENT (HTE '11) were held in Florence, Italy, August 23-25, 2011. The conferences provided a platform to discuss mathematical modeling in fluid mechanics, convection, heat and mass transfer, flow visualisation, biofluids, aerodynamics, aeroelasticity, aeronautics, computational fluid dynamics, flow measurement, hemodynamics, quantum hydrodynamics, aviation, refrigeration, heat exchangers, climatology, geoscience, solar energy, remote sensing, recycling, waste logistics, sea science, risk analysis, alternative fuels etc. with participants from all over the world, both from academia and from industry.

Their 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 these conferences 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.

Conferences such as these 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

Similarity Solutions for Steady Boundary Layer Equations



Professor Gabriella Bogнар

University of Miskolc

HUNGARY

E-mail: matvbg@uni-miskolc.hu

Abstract: Similarity analysis of the boundary flow over a flat surface in a non-Newtonian fluid is considered. Many of the non-Newtonian fluids which occur in practical applications, such as molten plastics, polymers, foods exhibit the so-called Ostwald-de-Waele power law nonlinearity.

Introducing the stream function in governing partial differential equations of mathematical models of various physical processes and choosing the similar variables we obtain the boundary value problem for the similar ordinary differential equation or their system. These similar equations have different type of non-linearity and depend on parameters.

We shall study the analytic solutions to different problems: boundary layer flow past a stationary surface or boundary layer flow over a solid surface continuously moving in a fluid, etc.

Brief Biography of the Speaker:

Professor Bogнар received the M.Sc. in Mechanical Engineering from University of Miskolc, Miskolc, Hungary, Ph.D. and 'Candidate' degree in mathematics from the Hungarian Academy of Sciences. Since her graduation she has been teaching different subjects of mathematics for undergraduate, graduate and doctoral students at University of Miskolc. She was conferred the postdoctoral lecture qualification (Dr. habil) in 2006. Her research interests include boundary and eigenvalue problems of nonlinear ordinary and partial differential equations. Gabriella Bogнар has authored/edited 11 books, and published over 80 research papers. She also serves as the Vice Dean for Research and International Affairs at the Faculty of Mechanical Engineering and Informatics, University of Miskolc.

Plenary Lecture 2

Series Solution of an Integro-Differential Equation



Professor Olga Martin
Applied Sciences Faculty
University "Politehnica" of Bucharest
Splaiul Independentei 313
Bucharest, ROMANIA
E-mail: omartin_ro@yahoo.ro

Abstract: The integral-differential equations describe many physical phenomena in different fields of the science and nuclear engineering. The resolution of these equations is the subject of several papers in which the authors have approached in most cases numerical methods: the finite element method, Monte Carlo, truncated series of Chebyshev polynomials, the fictitious domain method, SN method.

In this paper we present an algorithm based on the homotopy perturbation method (HPM) to solve the homogeneous boundary value for a transport equation, whose solution is the density of particles. The homotopy perturbation method is a coupling of traditional perturbation method and the homotopy function in topology that continuously deforms the given problem to another, which can be easily solved. It uses an embedding parameter p as a "small parameter", a power series in p and finally, using the techniques of HPM, the solution of the given problem will be the sum of a series.

The new version of He's homotopy method upon which our algorithm is built yields rapid convergence of the solution series and usually only a few iterations lead to high accuracy solutions. A numerical example proves the validity and the great potential of this new homotopy method for particle transport problems.

Brief Biography of the Speaker:

Olga Martin graduated the Faculty of Mathematics and Mechanics, University of Bucharest, Romania. She received his PhD in mathematics with the specialization in Dynamic Plasticity with paper work 'Applications of the Finite Element Method in Dynamic Plasticity'. During of twenty years, she had been senior researcher in Aircraft Institute, Strength Materials Department. Technical experience: structural strength computing reports using ANSYS program (wing-fuselage, fuselage frame, fin, elevator, rudder and aileron), dynamic and static test-programs for aircraft structures, fatigue test-programs for aircraft structures, iterative methods for the study of the reactions, which correspond to movable control surfaces, attached at n – points to an elastic structure and program of this, static and fatigue computation of the propeller (mono-bloc hub, blades and blades retention system).

Nowadays, she is Professor at Applied Sciences Faculty, University "Politehnica" of Bucharest. Fields of specialization: Mathematical Analysis, Mathematical Physics, Computational and Experimental Solid Mechanics, Numerical Analysis, Statistical Calculus. She has published over 90 research papers and 18 books.

Member of the editorial boards: Politehnica Sci. Bull. Series A, WSEAS Transactions on Applied and Theoretical Mechanics, WSEAS Transactions on Mathematics and she was involved in the program/organizing committees for many international conferences.

Membership of Professional Societies: Society of Computer Aided Engineering – Member National Union of Romanian Scientists (Founding member), Balkan Society of Geometers member, Romanian Society of Mathematicians.

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Scientific Evaluation Societies: RELANSIN, University "Politehnica" of Bucharest, ARACIS, Bucharest, Bucharest, National Science Fund of Bulgaria.

Plenary Lecture 3

Control by Laminar-Turbulent Transition in Boundary Layers



Professor Sergey A. Gaponov

Khristianovich Institute of Theoretical and Applied Mechanics (ITAM)

SB RAS, 630090, Novosibirsk, RUSSIA

E-mail: gaponov@itam.nsc.ru

Abstract: In the lecture various control methods by laminar -turbulent transition of a gas flow in boundary layers of flying apparatus are discussed. Control methods are divided into three classes. The first of them is called "passive". This method is based on formation of profiles of stationary flow parameters in laminar boundary layers, which are stable to small disturbances. It is reached by gas suction from a boundary layer, cooling of a surface or flow acceleration by a longitudinal pressure gradient. Often the second of them is named the active control method. In this case perturbations are entered into a flow with an opposite phase in respect of developing disturbances in boundary layers. At last in the third method the laminar -turbulent transition control is realized by surface properties. In the lecture two surface types are considered: porous and flexible. All control methods are based on the theoretical analysis and confirmed by experiment. Subsonic, supersonic and hypersonic currents are considered. It is shown that for stabilization of the subsonic and moderate supersonic flows two first methods are most effective. In case of hypersonic flows for these purposes it is possible to use porous coverings.

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

Brief Biography of the Speaker:

Sergey Gaponov graduated from the Physics Department of Novosibirsk State University, Russia in 1964. With 1965 till April he works in the Khristianovich Institute of Theoretical and Applied Mechanics of Siberian Branch of Russian Academy of Science as Junior and Senior Scientific Researcher, Head of Laboratory. Now he is Main researcher of the same Institute. With 1992 he works also as Professor of the Department of Theoretical Mechanics, Novosibirsk State University of Architecture and Civil Engineering. S. Gaponov is the expert in a field of the fluid and gas mechanics. The basic directions of his scientific activity are connected with researches of hydrodynamic stability, non-stationary processes and the turbulence occurrence in supersonic gas flows. He defended the candidate thesis "Stability of the incompressible boundary layer on a permeable Surface" (1971) and doctor thesis (physics and mathematics) «Development of disturbances in a supersonic boundary layer» (1987). He is member of Council on a defence of doctoral theses at Institute of Theoretical and Applied Mechanics, member of Russian National Committee on Theoretical and Applied Mechanics, member of the International Scientific Committee on Fluid Mechanics and Aerodynamics. The prize of Zhukovsky was awarded to him. There are many grants for fundamental research in which he took part: Grant of International Science and Technology Center: ISTC-128-96 investigator, Grants of Russian Foundation for Basic Research (team leader.) He took part in work of numerous scientific conferences, including the Fluid Mechanics and Aerodynamics conferences. Number of his papers in refereed journals is more than 140. Two books were published.

Plenary Lecture 4

Electro-Hydrodynamic Instabilities of Jets



Professor Daniel N. Riahi

Department of Mechanical Science and Engineering
University of Illinois at Urbana-Champaign
USA

also with:

Department of Mathematics
University of Texas-Pan American
USA

E-mail: driahi@utpa.edu

Abstract: In the first part of this lecture we review modeling and analyses that have been carried out in the past for electrically driven jet flows and the associated instabilities with important applications in electro-spinning. Next, we consider the relevant governing equations for both linear and nonlinear electrically driven jet flows and their associated temporal and spatial instabilities. Such jets can be driven by either constant or variable applied field. Under certain assumptions, scaling and conditions, we will derive mathematical models for the linear & nonlinear stability systems. We then determine linear and nonlinear solutions for some modes of instabilities of the resulting systems. We explain the properties of these solutions and conditions under which they can be dominant. We also compare the results with the available experimental results. More recent developments including instabilities under different equilibrium states as well as significant jet radius reduction due to certain instabilities and the implications with respect to production of nano-scale fibers will be discussed. In the last part of the lecture, we point out at future studies, directions and important questions that need to be resolved by future investigations on this topic.

Brief Biography of the Speaker:

Daniel N. Riahi served as Full Professor at The University of Illinois at Urbana-Champaign (UIUC) from 1995 to 2005, as Professor Emeritus at UIUC since 2005 with the home Dept of Mechanical Science and Eng (MechSE), and as Full Professor in the Dept of Math at University of Texas-Pan American since 2006. Dr. Riahi's research work & interest include studies in convection, flow instabilities & turbulence, flow during solidification & crystal growth, electromagnetic applications, and math modeling and theoretical developments with applications to eng and physical sciences. His research accomplishments include new theories and a number of discoveries in fundamental areas of convective and shear flows, some of which were already confirmed by the experimental studies. Professor Riahi received Appreciation Letters, Service Recognition Award & Certificates, Honorary Title Award & Research Awards from UIUC. He is member of over seven professional societies and a Fellow of Wessex Institute of Great Britain. He is author of Chapters in a book that won the Best Basic Science Book-Award by IAA. He was awarded NSF Grants, UIUC-RB & UTPA-FRC Grants, NCSA Awards and supervised NASA Sponsored Res. Projects. He presented many Invited Lectures and several Plenary Lectures at National & International Conferences. He is Editor and Editorial Board Member of over 20 technical journals and book series. He is author of over 330 publications mostly published in rigorously refereed journals, including books, invited articles, review articles and chapters of books.

Plenary Lecture 5

Scale Invariant Model of Boltzmann's Statistical Mechanics and Universality of the Laws of Thermodynamics



Professor Siavash H. Sohrab

Robert McCormick School of Engineering and Applied Science
Department of Mechanical Engineering
Northwestern University, Evanston, Illinois 60208
USA
E-mail: s-sohrab@northwestern.edu

Abstract: A scale invariant model of statistical mechanics of Boltzmann is described and employed to derive the invariant modified forms of the first and the second laws of thermodynamics. The nature of De Pretto number 8338 that occurs in his mass-energy equivalence equation (De Pretto, 1903)

$$E = mc^2 = mc^2/8338$$

and its identification as the universal gas constant are discussed. The invariant model of statistical mechanics is also shown to reveal the universal nature of the laws of thermodynamics in accordance with the perceptions of Boltzmann (Renn, 2000)

By application of the statistical method to arbitrary bodies (their treatment, so to say, as gas molecules with very many atoms) one can find mechanical systems which show full mechanical analogy with warm bodies,33 not only a partial one as the cyclic systems of Helmholtz. (Boltzmann and Babl 1905, p.549)

Invariant forms of Boltzmann distribution function, Planck energy spectrum as well as Maxwell-Boltzmann speed distribution for equilibrium statistical fields including that of isotropic stationary turbulence are presented. The results lead to the definitions of (electron, photon, neutrino) respectively as the most-probable equilibrium sizes of (photon, neutrino, tachyon) clusters. A scale-invariant model of statistical mechanics is also applied to derive the invariant forms of the conservation equations for mass, energy, and linear and angular momentum. The physical basis for the coincidence of normalized spacings between zeros of Riemann zeta function and the normalized Maxwell-Boltzmann distribution and its connections to Riemann Hypothesis are examined.

Brief Biography of the Speaker:

Siavash H. Sohrab received his PhD in Engineering Physics in 1981 from University of California, San Diego, his MS degree in Mechanical Engineering from San Jose State University in 1975, and his BS degree in Mechanical Engineering from the University of California, Davis in 1973. He joined Northwestern University in 1982 and since 1990 he is Associate Professor of Mechanical Engineering at the Northwestern University.

Plenary Lecture 6

Thermal Energy Storage using PCMs



Professor Mihai Cruceru

Energy Department, Engineering Faculty
"Constantin Brancusi" University of Targu-Jiu
Bd. Eroilor 30, Targu-Jiu, Gorj, Romania, RO 210152
E-mail: cruceru@utgjiu.ro

Abstract: Buildings are the largest end user of energy, since 40% of all energy is used in the residential/tertiary sectors. The energy demand for cooling or heating applications has been growing constantly over the past few years. One main reason for this development is that new buildings are often constructed by light materials and the lack of thermal storage capacity leads to fast overheating or subcooling of the building.

The need of thermal energy storage may often be linked to the following cases: there is a mismatch between thermal energy supply and energy demand; when intermittent energy sources are utilized; for compensation of the solar fluctuation in solar heating systems.

The use of thermal storage walls that serve both as solar collector and thermal storage is well known. The wall is usually composed of masonry or containers filled with water to provide sensible heat storage resulting from the specific heat capacity of a material as it increases in temperature.

Sensible heat energy storage has the advantage of being relatively cheap but the energy density is low and there is a gliding discharging temperature. To overcome these disadvantages phase change materials (PCMs) can be used for thermal energy storage.

PCMs are materials capable of increasing thermal inertia of buildings without increasing the thickness of walls, for instance. In comparison with other thermal storage materials, such as concrete or water, PCMs have a higher energy storage density. In that way, one can achieve the same goal with less material. On the other hand, PCMs also allow the storage and the release of thermal energy at an almost constant temperature.

A research group from "Constantin Brancusi" University from Targu-Jiu patented a new type of composite wall system incorporating PCMs and evaluated its potential for air conditioning/heating energy savings in continental temperate climate.

The novelty of the wall system consists of the fact that two PCM wallboards, impregnated with different PCMs are used. The structure of the new wall system is that of a three-layer sandwich-type insulating panel with outer layers consisting of PCM wallboards and middle layer conventional thermal insulation.

The PCM wallboard layers have different functions: the external layer has a higher value of the PCM melting point and it is active during hot season and the internal layer with a PCM melting point near set point temperature for heating is active during cold season. A year-round simulation of a room built using the new wall system was carried out and the effect of PCM presence into the structure of the wall system was assessed. It was found that the new wall system contributes to annual energy savings and reduces the peak value of the cooling/heating loads.

Brief Biography of the Speaker:

Mihai CRUCERU, born on 02.07.1967 in Targu-Jiu, Romania, graduated from Installations for Buildings Faculty, Technical University of Civil Engineering Bucharest (1991), where he obtained also his PhD (1998). He worked for one year as HVAC engineer and he joined in 1992 the Energy Department from "Constantin Brancusi" University Targu-Jiu where he is now professor of Heat Transfer and Energy Management. He was Dean, Head of Department for Education Quality, and now he is Vice-Rector for Education. His research is focused on Heat and mass transfer, Thermal equipment design and Energy efficiency. He is Energy auditor and Thermal equipment and fluid systems expert. He was involved, as director or researcher, in 18 national and international research projects. He published 11 books and more than 110 articles in relevant journals and conference proceedings.

Plenary Lecture 7

Analysis of Heat Transfer in the Combustion Chamber of an Internal Combustion Engine Using the Thermal Networks



Assoc. Prof. Krisztina Uzuneanu

Thermal Systems and Environmental Engineering Department

“Dunarea de Jos” University of Galati

47 Domneasca street, 800008 Galati, Romania

E-mail: kuzuneanu@ugal.ro

Abstract: The heat transfer processes in an internal combustion engine can be modeled with a variety of methods. These methods range from simple thermal networks to multidimensional differential equation modeling. Thermal network models, using resistors and capacitors, are very useful for rapid and efficient estimation of conduction, convection and radiation heat transfer processes in engines. Using a thermal network, the significant resistances to heat flow, and the effects of changing material thermal conductivity, thickness, and coolant properties can be easily determined.

The thermal stresses in the cylinder head and in the piston head of an internal combustion engine are determined as a function of the level of temperatures, the temperature difference between different parts and the heat transfer between parts. These further depend on the speed and the way the heat is transferred to the parts, on the part shape, their thermal conductivity and cooling.

Measuring the temperatures in different parts of the cylinder head and the piston head, the cooling can be adjusted or the materials can be improved, or even the properties of the fuels can be improved. We can take into consideration the mixture of a small quantity of alcohol with gasoline in order to reduce the level of temperature.

Brief Biography of the Speaker:

Dr. Krisztina Uzuneanu graduated Faculty of Mechanical Engineering of University “Dunarea de Jos” of Galati in 1984 and she obtained the title of Doctor Engineer in 1998.

Since 1987 she followed the academic carrier at Dunarea de Jos University of Galati as assistant, lecturer and associate professor. Dr. Uzuneanu is a visiting professor at different universities: Universidade do Minho, Portugal, Universita degli Studi di Genova, Italy, Universita degli Studi di Salerno, Italy, Pannon University Veszprem, Hungary, Erciyes University Kayseri, Turkey and visitor scientist of of Universidade do Minho Guimaraes, Portugal where she was awarded with a post-doc NATO grant in 2002 - 2003.

Research fields are connected with applied thermodynamics, alternative fuels for internal combustion engines, modeling the thermal stresses of different parts of internal combustion engines, renewable energy and pollution.

Dr. Uzuneanu published over 100 articles in national and international conferences proceedings and she is author of 3 books.

The research work was done as member of 20 research contracts financed by European Commission and Romanian Ministry of Education and Research and director of 5 research contracts financed by industry.

Dr K. Uzuneanu is member of Romanian Society of Thermodynamics since 1990 and member of Balkan Environmental Association since 2011.

Plenary Lecture 8

Boiling Heat Transfer Enhancement Using Nano and Micro Technology



Professor HyungHee Cho
 School of Mechanical Engineering
 Yonsei University, Seoul, Korea
 E-mail: hhcho@yonsei.ac.kr

Abstract: A lot of the previous studies on boiling heat transfer have been reported since 1950s. They have investigated the typical researches on the theoretical analyses and the experimental approaches on the prediction and the evaluation of boiling phenomena. Since 1990s, according to the wide spreading of MEMS technology, surface manipulation technique has been widely applied to enhance boiling heat transfer performance. Based on the application of MEMS fabrication technology, it could be also feasible to manipulate surface chemical properties resulting in surface wettability control. Moreover, the previous approaches based on microscale surface treatment have been advanced into the application of nanotechnology, which deals with more minute surface morphology. As nanotechnology became to be widely used in industrial fields and academic researches, nanoscale surface treatments even on boiling heat transfer has been identified based on various experimental approaches. In this lecture, the micro-nanoscale surface manipulation techniques for the enhancement of boiling heat transfer performance are summarized. First, surface manipulation via silicon nanowire arrays (SiNWs) is conducted as an effective method to increase surface roughness extremely and create natively formed vapor bubble seeds, which are favorable to boiling heat transfer, with microscale dimensions by coalescence of SiNWs. Second, the enhancement of boiling performance is verified using micro-nano hybrid structure fabrication. In details, multiscale structure, which consists of SiNWs and microscale patterns, is introduced accompanying wicking phenomena by nanoscale structure and surface area increase and bubble seeds formation by microscale structure. Then pool boiling performance is experimentally verified in terms of the geometric parameters related to the designing of multiscale structures. Finally, it is demonstrated that the application of optimal multiscale structure considering the boiling characteristics can enhance boiling performance compared with results on a bare surface and previously reported ones via artificial structures.

Brief Biography of the Speaker:

HyungHee Cho received the B.S. and M.S. degrees in mechanical engineering from Seoul National University, Seoul, Korea, in 1982 and 1985, respectively, and Ph.D. degree in mechanical engineering from University of Minnesota, Minneapolis, MN in 1992. From 1992 to 1995, he was research associate in University of Minnesota. In 1994, he joined Minnesota Supercomputer Institute as a research associate. In 1995, he joined the Department of Mechanical Engineering, Yonsei University, Seoul, Korea, where he is currently a full professor in the School of Mechanical Engineering. From 2003 to 2005, he was the Chairman of Department of Mechanical Engineering at Yonsei University. From 2005 to 2007, he held position as the Associate Dean of College of Engineering at Yonsei University. He is currently the director of The Low Observable Technology Research Center.

His research interests include heat transfer and flow control/design in macro-scale devices as well as micro/nano-scale components. For macro-scale devices, he has been working on heat transfer in turbomachineries, rockets/ramjets and nuclear reactors. Especially, with intensive research on various cooling techniques such as film cooling, internal passage cooling, and impingement/effusion cooling, he has accomplished major research achievements including numerous papers and patents. For nuclear reactors, he has been working on flow-induced vibration and boiling heat transfer enhancement by controlling flow characteristics and heat transfer. For micro/nano-scale components, he has worked on thermal transport phenomena in low dimensional materials as well as thermal management in electronics and semiconductor devices. Recently, he has been working on boiling heat transfer enhancement using nano and micro technology.

He is a recipient of numerous awards such as KSME Scientific Achievement Award (2000), Yonsei Academic Achievement Award (2001), KSFTS best paper award (2006) and KFMA Scientific Achievement Award (2008). Dr. Cho is a Fellow of the American Society of Mechanical Engineers, a Scientific Council Member of the International Centre for Heat and Mass Transfer (ICHMT), and an Associate Member of the Korea Academy of Science and Technology (KMST). He is also a committee member of ASME K-14 (Heat Transfer in Gas Turbine) Committee and vice president of KSME Energy and Power Division. He serves on the editorial board of JP Journal of Heat and Mass Transfer, Advances in Mechanical Engineering, and International Journal of Fluid Machinery and Systems.

Plenary Lecture 9

Various Aspects of Measurement of Uniaxial Elongational Viscosity of Polymer Melts



Dr. Petr Filip

Institute of Hydrodynamics, Acad. Sci. Czech Rep.
Pod Patankou 5, 166 12 Prague 6, Czech Republic
E-mail: filip@ih.cas.cz

Abstract: Experimental determination of uniaxial elongational viscosity of polymer melts still raises a number of basic questions concerning an approach how to carry out the measurements. In contrast to a determination of shear viscosity this problem is much more complicated including the theoretical background of the whole experimental process. As a possible alternative to the classical devices of Meissner and Munstedt types for measurement of uniaxial elongational viscosity there has been recently proposed and tested so-called SER Universal Testing Platform (M.L.Sentmanat, US Patent No. 6578413) enabling its application in the traditional commercial rotational rheometers without any additional alteration of the host system. The aim is to demonstrate the invariance of dimensions of the rectangular polymer samples used with respect to the obtained values of uniaxial elongational viscosity. This is based on summarization of the experimental results taken within the wide range of geometrical parameters generating the dimensions of the experimental polymer samples used (viz. their widths and thicknesses).

Brief Biography of the Speaker:

Petr Filip graduated from the Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic in 1976. He completed his Ph.D. study at the Institute of Mathematics, Acad. Sci. Czech Rep., his Ph.D. Thesis was devoted to oscillatory solutions of partial differential equations. Since 1980 he has been with the Institute of Hydrodynamics, Acad. Sci. Czech Rep., Prague, for many years as a head of the Department of Chemical Engineering where he was interested in fluid mechanics, especially theory of jets and mixing. Later on he was appointed to the position of a scientific secretary (up to now), at present his sphere of interest is rheology (flow of non-Newtonian liquids). He is an author (co-author) of more than 100 contributions published in international journals and conference proceedings.

Plenary Lecture 10

Economic Evaluation of Fluegas Re-Mediation by RDF and Solar Energy



Professor Martino Paolucci

Co-authors: C. Borgianni, U. Mazzanti, G. DiLuzio
SEAR-Parco Scientifico e Tecnologico di "Tor Vergata"

E-mail: mpturbine@virgilio.it

P. DeFilippis

Dipartimento Ingegneria Chimica – Università di Roma "La Sapienza"
ITALY

Abstract: In recent years a big effort is aimed at the study of technology for carbon dioxide reduction in flue gas. The separation of CO₂ is a drawback for any operation of remediation, and therefore the best system is the remediation of the fluegas without any treatment. In this paper it is examined whether the reaction between RDF and fluegas, supported by the solar energy is attractive from an economic point of view.

First of all, the advantage of using RDF in this remediation instead of its use as a raw-material in gasification is examined. The use of RDF in the remediation of the fluegas is advantageous if it is considered the annual production of RDF in agglomerates containing less than 500000 inhabitants.

Besides, the effect of the annual production of RDF, carbon tax, manpower and investment cost is examined. The carbon tax increases its importance as much as it increases as the content of CO₂ in the fluegas.

The influence of the other parameters is rather independent of the ratio between carbon dioxide and steam in the fluegas while it is more pronounced the variation of the energy cost as a function of the made investment if the plant size is reduced.

Further, a statistical equation were found, which takes into account the effect of the parameters on the energy cost.

Plenary Lecture 11

On One Nonlinear System Associated with the Penetration of an Electromagnetic Field in a Substance

**Professor Temur Jangveladze**

Ilia Vekua Institute of Applied Mathematics
Ivane Javakhishvili Tbilisi State University

Caucasus University

GEORGIA

E-mail: tjangv@yahoo.com

Abstract:

Nonlinear parabolic systems of equations arise in studying of many scientific and practical processes. One type of such models appear in studying of electromagnetic diffusion simulation. Process of penetration of electromagnetic field into a substance is accompanied with thermal phenomena, which essentially changes process of diffusion and complicates corresponding system of Maxwell's equations. Mentioned system, taking into account Joule-Lenz's rule and thermal conductivity, has the following form:

$$\frac{\partial \theta}{\partial t} = \nu_m (\text{rot } H)^2 + \text{div}(\kappa \text{ grad } \theta), \quad \frac{\partial H}{\partial t} = -\text{rot}(\nu_m \text{ rot } H), \quad (1)$$

where $H = (H_1, H_2, H_3)$ is a vector of the magnetic field, θ is temperature, ν_m and κ are characteristics coefficients of the substance. As a rule these coefficients are functions of argument θ . Beside of essential nonlinearity, complexities of the mentioned system is caused by its multidimensionality. Naturally arises the possibility of reduction to suitable one-dimensional models. Complex nonlinearity dictates also to split along the physical process and investigate basic model by them. In particular, it is logical to split system (1) into following two models:

$$\frac{\partial \bar{H}}{\partial t} = -\text{rot}(\nu_m(\bar{\theta}) \text{ rot } \bar{H}), \quad \frac{\partial \bar{\theta}}{\partial t} = \nu_m(\bar{\theta})(\text{rot } \bar{H})^2 \quad (2)$$

and

$$\frac{\partial \bar{\theta}}{\partial t} = \text{div}(\kappa(\bar{\theta}) \text{ grad } \bar{\theta}). \quad (3)$$

In (2) Joule-Lenz's rule, while in (3) process of thermal conductivity are considered. Note that, system (2) can be reduced to integrodifferential form. Our aim is to construct and study additive analogues bases on models (2),(3).

Our main attention is paid on one-dimensional case of (1) and it splitted (2),(3) analogous. The difference scheme and semidiscrete additive model are constructed. The theorems of convergence of approximate solution to exact ones are established. Finally the results of computing model problems are given.

Brief Biography of the Speaker:

Prof. Temur Jangveladze graduated from Ivane Javakhishvili Tbilisi State University, Department of Applied Mathematics and Cybernetics in 1977. Post graduate study under supervision Prof. Andria Bitsadze. T. Jangveladze was Junior Researcher (1977-1983), Researcher (1983-1988), Senior Researcher (1988-1998), Leading Researcher (1998-present) at Ilia Vekua Institute of Applied Mathematics of Ivane Javakhishvili Tbilisi State University. Invited

Assistant (1981-1984) and Invited Docent (1984-1988), Docent (1988-1998), Professor (1998-2009), Invited Professor (2009-present) at Ivane Javakhishvili Tbilisi State University. Professor at Ilia State University (2006-2010). Invited Professor (2001-2010), Professor (2010-present) at Caucasus University. Since 1977 till now read the lectures in Numerical Analysis, Numerical Solutions of Differential Equations, Nonlinear Partial Differential and Integro-differential Models, Mathematical Modeling and etc. In 1984 defended Ph.D. thesis in specialty "Computational Mathematics". In 1998 defended a thesis for a Doctor of Science (Habilitation) Degree in specialty "Theoretical Bases of Mathematical Modeling, Numerical Methods, Program Complexes". Field of his scientific interests is Differential and Integro-Differential Equations and Systems, Mathematical Modeling, Numerical Analysis, Nonlocal Boundary Value Problems and etc. The full list of publications comprises more than 110 scientific papers and text books. He is editor of journal "Reports of Enlarged Session of the Seminar of I.Vekua Institute of Applied Mathematics" and member of editorial board of several international scientific journals. Was the member of international program committee and the participant of many international scientific conferences. Prof. T. Jangveladze is a head of Department of Informatics of Tbilisi International Centre of Mathematics and Informatics (TICMI). Chair of the Enlarged Sessions of the Seminar of Ilia Vekua Institute of Applied Mathematics, Section of Ordinary and Partial Differential Equations and Optimal Control.

Plenary Lecture 12

Numerical Simulation of Heat and Mass Transfer Problems of Agroindustrial Interest via Lattice-Boltzmann Method



Professor Jose A. Rabi

Faculty of Animal Science and Food Engineering
University of Sao Paulo - Pirassununga Campus
Av. Duque de Caxias Norte 225, 13635-900, Pirassununga, SP
Brazil
E-mail: jrabi@usp.br

Abstract: Numerical simulation of food and bioprocesses has continuously increased not only because its importance has been recognized but also as suitable computational tools have been developed and employed. Accordingly, lattice-Boltzmann method (LBM) has become an alternative and powerful numerical technique to simulate a variety of transport phenomena. This lecture particularly focuses on LBM fundamentals as well as on its application to problems of agroindustrial interest involving heat and mass transfer. LBM treats the medium as a collection of constituent particles occupying and traveling between a number of lattice sites while following two computational steps referred to as “streaming” and “collision”. During the later (which renders time evolution), particles mutually collide and are rearranged as they arrive at lattice sites. During the former (which yields spatial evolution), collision results are transported to adjacent sites as particles travel along pre-defined directions. By imposing that such particle dynamics obey basic conservation principles while being isotropic, macroscopic medium behavior can be properly simulated. LBM simulation results are presented and discussed for processes like supercritical fluid extraction and biospecific affinity chromatography in fixed-bed equipment (which evoke convective-diffusive species transfer besides sorption-desorption kinetics between solid and fluid phases) as well as blast-cooling of catering meals (which involves heat transfers under either zero-order or first-order modeling with respect to spatial variation of foodstuff temperature).

Brief Biography of the Speaker:

Jose Rabi received B.Sc. degree in Applied Physics from the University of Sao Paulo in 1995, M.Sc. degree in Mechanical Engineering from the Aeronautical Institute of Technology in 1998 and Ph.D. degree in Mechanical Engineering from the University of Campinas in 2002 (all aforesaid degrees in Brazil). In 2003-2004 he joined the Department of Mechanical and Manufacturing Engineering, University of Calgary (Canada), as a postdoctoral fellow and in 2009-2010 he joined the Research Unit for Refrigeration Process Engineering (GPAN) of CEMAGREF (France) as a research fellow. From 2002 to 2004, he was affiliated to the Catholic University of Minas Gerais (Brazil), mostly teaching Numerical Methods as well as Transport Phenomena to Civil Engineering undergraduate courses, and since 2005 he has been a full professor at the Faculty of Animal Science and Food Engineering, University of Sao Paulo. His current research interests include modeling and simulation of agroindustrial processes, with particular attention to lattice-Boltzmann methods. He is author of about 30 papers published in international journals and conference proceedings and also of 2 invited international book chapters.

Plenary Lecture 13

Thermoelectricity: From Quadrupole Formulation to Space Applications



Associate Professor Myriam Lazard
Institut PPrime UPR 3346, Departement Fluide
Thermique et Combustion
ENSIP, B25, Campus Sud, 2 rue Pierre Brousse
B.P 633, 86022 Poitiers Cedex, FRANCE
E-mail : myriam.lazard@univ-poitiers.fr

Abstract: There is an increasing interest in thermoelectric devices even if the efficiency is rather low. Many fields such as aerospace, automotive or building applications are concerned. It is then interesting to model the phenomena involved especially into the thermoelectric legs and to try to optimize the design of the thermoelements.

In a first part, a semi-analytical method has been developed to solve easily the transient case. The Joule contribution is taken into account (introducing a source term in the heat transfer equation) and the effect due to the Thomson coefficient is considered whereas it is often neglected. Thanks to the expressions of the temperature and of the heat flux expressed in the Laplace domain, the quadrupole method is performed. No mesh is required. The whole matrix formulation is given for different initial conditions.

In the second part, the focus is put on the design of a thermoelement applied to Radioisotope Thermoelectric Generators (RTGs). RTGs work by converting heat from the natural decay of radioisotope materials into electricity; the two junctions of the thermoelement are kept at different temperatures and this temperature difference is relatively large. To achieve a better efficiency and as no single thermoelectric material presents high figure of merit over such a wide temperature range, it is therefore necessary to use different materials and to segment them together in order to have a sandwiched structure. In this way, materials are operating in their most efficient temperature range. In this paper, the design and the optimization of segmented thermoelement are proposed and explained on a real test case considered by the Russian firm BIAPOS.

Brief Biography of the Speaker:

Myriam Lazard is associate professor at Institut PPrime University of Poitiers since 2010. Previously she was associate professor, at the Institute in Engineering and Design (InSIC), Ecole des Mines (2002-2010). Her PhD was on the "Modelling of the combined conductive-radiative heat transfer in a semi-transparent medium. Parameters estimation", Lab. Energetics & Mechanics Theoretical and Applied, (LEMTA), Institut National Polytechnique de Lorraine (2000). Her research interests include heat transfer in manufacturing processes, radiative transfer in semi-transparent media, inverse problems, parameters estimation and thermoelectricity.

She is member of the editorial board of the journal CESES, and Editor in Chief of WSEAS TRANSACTIONS on HEAT and MASS TRANSFER ISSN: 1790-5044.

Plenary Lecture 14

Conservative Averaging Method for Linear and Non-Linear Heat Problems



Professor Andris Buikis
University of Latvia
Member of Latvian Parliament
RIGA, Raina bulv. 29-310, LV1459
LATVIA
E-mail: buikis@lu.lv

Abstract: This conservative averaging method was developed 30 years ago in my doctor dissertation. Now I and my collaborators had generalized this method for Descartes', cylindrical and spherical system of coordinates.

By modeling practically interesting processes, very often we need to consider the situation, when the medium has a layered structure. Speaking mathematically, such situation can be described by PDE (or its system) with piecewise constant/continuous coefficients. In this lecture I'll show how conjugations conditions, non-ideal contact conditions etc. and their generalizations can be obtained by our original method of conservative averaging (CAM). The usage of CAM for separate relatively thin sub-domain or/and for sub-domain with large medium characteristic, leads to reduction of domain, in which the solution must be found. To apply CAM procedure for several layers, it is necessary to construct special type of polynomial and rational spline, which interpolates the integral averaged values of the solution. New type of spline was developed for non-continuous solutions. In this case the original problem with discontinuous coefficients from transforms to problem with continuous coefficients in . The usage of CAM for ill-posed inverse problems in some cases transforms them to well-posed inverse problems.

We demonstrate this method for linear, non-linear heat transfer problems: convective conductive stream in layered system, intensive steel quenching, heat exchange in system with extended surface and electrical fuse.

Brief Biography of the Speaker:

Andris Buikis received the M.S. in numerical mathematics from University of Latvia (Faculty of Physics and Mathematics) in 1963 and Dr.math. (Candidate of Science in former USSR), University of Latvia, 1970. He was Junior Researcher, Senior Researcher, Computing Centre, University of Latvia, 1962 – 1972. Assistant Professor and Head of Chair of Applied Mathematics, 1972 – 1976 and Head of Chair of Differential Equations and Numerical Methods, Faculty of Physics and Mathematics, University of Latvia, 1976 – 1984. Dr.habil.math. (Doctor of Science in former USSR), University of Kasan, Russia, 1988. Professor, University of Latvia, 1991. Director, Institute of Mathematics, Latvian Academy of Sciences and Latvian University, 1991 - 1996; 2003 – 2006 and Director, Science and Dialogue Centre of Latvia, 1993 -2007. Head of Laboratory of Mathematical Technologies, Institute of Mathematics and Computer Science, University of Latvia 2006-2010.

In 2010 he was elected as Member of Saeima (Latvian Parliament). Full Member, Latvian Academy of Sciences, 1997. Member, Senate of the Latvian Academy of Sciences, 1994 –. The Latvian Academy of Sciences Piers Bohls Prize for a cycle of papers "Method of Conservative Averaging, Theory and Applications", 2005. Member of Editorial Advisory Board, Journal Mathematical Modelling and Analysis (The Baltic Journal on Mathematical Applications, Numerical Analysis and Differential Equations), Lithuania 1999- and Associate Editor of WSEAS Transactions in Heat and Mass Transfer 2007-.

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