JFM Symposia:

From Fundamentals to Applied Fluid Mechanics

SPEAKER BIOGRAPHIES AND ABSTRACTS

11-12 DECEMBER

IIT, MUMBAI

Day 1 - JFM Symposium

Day 2 - Publishing Workshop

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

CAMBRIDGE UNIVERSITY PRESS

ABOUT THE SYMPOSIA

We are delighted that you have chosen to attend the first series of mini-symposia organised jointly by the Editorial Board members of the *Journal of Fluid Mechanics* and world-class researchers based in India, notably Mumbai, Bangalore and Chennai.

The aim of these symposia is to bring together leading researchers from across the breadth of fluid mechanics – from fundamentals to applied interdisciplinary research including aeronautics, astrophysics, biology, chemical and mechanical engineering, hydraulics, materials, meteorology, oceanography, geology, acoustics and combustion.

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Manish Choudhary, *Cambridge University Press, Delhi, India*

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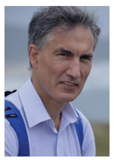
Dear Colleagues,

Cambridge University Press is delighted to be co-organising this JFM Symposium: From Fundamentals to Applied Fluid Mechanics, together with the Indian Institute of Technology Bombay. We would like to give special thanks to our hosts Professors Krishnendu Sinha and Rochish Thaokar, IIT Bombay, for their generous help and support of the meeting and for agreeing to co-host this symposium.

The *Journal of Fluid Mechanics* was founded in Cambridge by George Batchelor in 1956 and has become the leading journal in the field. The Journal has grown very significantly in capacity and in breadth, as indeed the subject of fluid mechanics itself has grown from traditional areas of engineering science to engage with almost every area of science and technology.

We are pleased to be joining colleagues from India to share our exciting ideas in research. And we are delighted to have this opportunity to share our experiences of scientific publication, whether as authors or editors, so that we can understand more clearly how the *Journal of Fluid Mechanics* can best serve the global scientific community.

We would like to thank all of speakers, organisers, editors and committee members especially our new JFM Associate Editor, Professor Prabhu Nott. We hope that all presentations will stimulate exchange of ideas, experiences and potentially foster future research collaborations. Welcome to what promises to be an exciting meeting!



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Dear Colleagues,

It is an honour for the fluid dynamics community at IIT Bombay to host the first JFM symposium in India. As part of the organising team, we welcome you to IIT Bombay, and wish you a fruitful and productive time at the symposium.

IIT Bombay was established in 1958, the second of its kind to be set up by Government of India, and it has grown from strength to strength to emerge as one of the top technical universities in the country. IIT Bombay campus is known for its natural beauty. Nestled between the Powai and Vihar lakes, it is surrounded by hills and is frequented by visitors from the wild because of the proximity to Sanjay Gandhi National Park. Being part of Mumbai, the busy financial capital of India, it enjoys excellent connectivity with all parts of the world. IIT Bombay is a preferred destination among aspiring students for undergraduate and graduate studies.

Fluid mechanics has been a traditional strength of the faculty and students at IIT Bombay. Fluid mechanics research covers a wide range of areas from complex fluids in chemical engineering, to hypersonic flows and shock waves to micro-fluidics and bio-fluid mechanics. Applications are in the areas of aerospace engineering, materials, manufacturing, energy, environment, and many other challenging and innovative topics.

At the symposium, there is an excellent line up of technical talks, with ample time for networking with the JFM editorial team. We look forward to interacting with the fluid mechanics community in and around Mumbai, and with the highly regarded editors of the *Journal of Fluid Mechanics*.

We thank you for your participation in this exciting event and for helping us to make the symposium a great success.

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11 December 2017

Time	Lecture	Chair
09.00-09.30	Opening speech from Cambridge University Press **Kathleen Too, *Cambridge University Press*** Opening speech from IIT Bombay **Krishnendu Sinha, *IIT Bombay*** **Rochish Thaokar, *IIT Bombay***	**Grae Worster**
09.30-10.00	Turbulent premixed flames in the context of hydrodynamic theory **Moshe Matalon, *University of Illinois at Urbana-Champaign***	
10.00-10.30	Search for higher-order continuum transport equations **Amit Agrawal, *IIT Bombay***	
10.30-11.00	Coffee/Tea break	
11.00-11.30	High Reynolds number wall turbulence: Universality, structure and interactions **Ivan Marusic, *University of Melbourne***	**Prabhu Nott**
11.30-12.00	Dynamics of rough particles in particle-laden turbulent shear flow: Fluctuating force model **Partha Sarathi Goswami, *IIT Bombay***	
12.00-12.10	Introduction to books @ Cambridge University Press **Manish Choudhary, *Cambridge University Press***	
12.10-13.00	Lunch	
13.00-13.30	Marine ice sheets **Grae Worster, *University of Cambridge***	**B. N. Raghunandan**
13.30-14.00	Intermittency as a transition route to combustion instability **Vineeth Nair, *IIT Bombay***	
14.00-14.30	Electrohydrodynamics of drops in AC/DC, low/high, Uniform/non-Uniform electric fields **Rochish Thaokar, *IIT Bombay***	
14.30-15.00	Shock-turbulence interaction: theoretical analysis and turbulence modeling for aerospace application **Krishnendu Sinha, *IIT Bombay***	
15.00-15.30	Coffee/Tea break	
15.30-16.00	Computational investigation and mechanistic modeling of subcooled flow boiling for nuclear engineering applications **Janani Sree Murallidharan, *IIT Bombay***	**Vinay Juvekar**
16.00-16.15	What does a JFM Editor look for when assessing a paper? **Grae Worster, *University of Cambridge***	**Kathleen Too**
16.15-17.15	JFM panel discussions **Grae Worster, *University of Cambridge*** **Moshe Matalon, *University of Illinois at Urbana-Champaign*** **Ivan Marusic, *University of Melbourne*** **Prabhu Nott, *Indian Institute of Science***	
17.15-17.30	Closing remarks **Grae Worster, *University of Cambridge*** **Krishnendu Sinha, *IIT Bombay*** **Rochish Thaokar, *IIT Bombay***	

Workshop with librarians and students

12 December 2017

Time	Lecture
09.00-10.00	Publishing workshop **Kathleen Too, *Cambridge University Press***
10.00-10.45	Awareness workshop on Cambridge Core **Gunjan Hajela, *Cambridge University Press***
10.45-11:15	Discussions and coffee break

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Grae Worster completed his PhD at the University of Cambridge, UK in 1983, has been an Instructor in Applied Mathematics at MIT and an Assistant Professor in Applied Mathematics and Chemical Engineering at Northwestern University. He is currently Professor of Fluid Dynamics in the Department of Applied Mathematics and Theoretical Physics, University of Cambridge. His research focuses on buoyancy-driven flows and phase change, particularly in situations where these two phenomena interact. In the context of climate change, he has combined mathematical modelling and laboratory experiments to understand and quantify the mechanisms affecting brine drainage from sea ice, the flow and stability of marine ice sheets and fundamentals of frost heave. Grae also teaches at the African Institute for Mathematical Sciences, from which he has written the book "Understanding Fluid Flow". He co-edited the book "Perspectives in Fluid Dynamics" with George Batchelor and Keith Moffatt.

Grae Worster has been an Associate Editor of the *Journal of Fluid Mechanics* since 1994 and is currently its Editor in Chief.

ABSTRACT

Title: Marine ice sheets

The equivalent of about 75 metres of sea-level are currently locked up in Antarctica as a continental ice sheet. Much of the West Antarctic Ice Sheet sits on bedrock that is a kilometre or two below current sea level, forming what is known as a marine ice sheet. As it flows outwards towards the continental margin, the ice sheet thins, eventually becoming sufficiently thin to float on the ocean as an ice shelf. Ice shelves calve icebergs from time to time, as we have witnessed recently when a giant iceberg calved from the Larsen C ice shelf. While this does not give rise to an immediate rise in sea level, ice shelves can buttress the ice streams that feed them, so collapse of an ice shelf can allow the ice streams to accelerate and thin, which does cause sea level to rise. The overall mass balance of a marine ice sheet is dominated by fluid-dynamical controls across the grounding line – the locus of where the grounded ice sheet first begins to float to form an ice shelf. I will describe some analogue laboratory experiments and associated fluid-mechanical models that help to elucidate the dynamics of marine ice sheets and their stability.

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Moshe Matalon received his undergraduate and Master's education at Tel Aviv University, followed by a Ph.D. in Mechanical and Aerospace Engineering from Cornell University in 1977. He has worked at Cornell University, the Polytechnic Institute of New York, Northwestern University, and since 2007 has been at the University of Illinois at Urbana-Champaign, where he is the College of Engineering Caterpillar Distinguished Professor. Matalon's research interests are in combustion theory, theoretical fluid mechanics and applied mathematics. He made significant and long lasting contributions to numerous areas of combustion science including the derivation and formulation of a hydrodynamic theory of premixed flames, a general description of the reaction zone structure of diffusion flames, studies of flame instabilities (linear and nonlinear) in various configurations, contributions to liquid droplet and solid particle combustion, understanding combustion at the microscale, and theories of turbulent flames in the flamelet regime of turbulent combustion.

Matalon was named Associate of the UIUC Center of Advanced Study in 2008, was elected Fellow of the American Physical Society in 1995, Fellow of the Institute of Physics in 1999 and Fellow of the American Institute of Aeronautics and Astronautics (AIAA) in 2012, and was recipient of several awards, including the AIAA Pendray Aerospace Literature Award in 2010, the AIAA Fluid Dynamics award in 2016 and the Numa Manson medal of the Institute for the Dynamics of Explosions and Reacting Systems (IDERS) in 2017.

Matalon has been an Associate Editor of the *Journal of Fluid Mechanics* since 2008.

ABSTRACT

Title: Turbulent premixed flames in the context of hydrodynamic theory

The notion of *laminar flamelet* has been a fundamental and constructive one in understanding the complex flame-turbulence interactions occurring during the propagation of premixed flames. The turbulent flame in this approach is viewed as an ensemble of stretched laminar flamelets, defined as thin reactive-layers embedded within the turbulent flow field. The basis for the flamelet concept lies in an asymptotic model - the hydrodynamic theory, that exploits the disparity between the distinct scales associated with the flow field, the diffusion processes, and the highly temperature-sensitive reaction rates. The idea led to a qualitative classification of possible flame-turbulence interactions, widely known as the "regime diagram of premixed turbulent combustion", and to the development of flamelet models based on a level-set approach in conjunction with a function that serves as a progress variable and allows tracking the evolution of the flame surface.

The present work is based on the hydrodynamic theory. The flame of thickness, assumed much smaller than the characteristic hydrodynamic length, is approximated by a surface that separates burned from unburned gases and propagates relative to the fresh combustible mixture at a speed that depends on the local mixture and flow conditions. The turbulent flow field is modified, in turn, by the gas expansion resulting from the heat released in the thin flame zone. Effects due to the flame thickness, such as differential diffusion or variations in the overall system pressure, can be studied by appropriately varying the Markstein length. The results, devoid of turbulence-modelling assumptions and ad-hoc coefficients, provide fundamental understanding of the influence of the system parameters, individually and collectively, on the turbulent propagation which is difficult to achieve in experiments. Evidently, the approach neglects possible modifications of the internal flame structure resulting from the turbulence and, therefore, strictly speaking falls within the "flamelet regime" of turbulent premixed flames.

A parametric study has been carried for mixtures with positive Markstein length (i.e., absence of thermo-diffusive instabilities), examining different factors that affect the propagation. The computations have been carried out for flame propagation in "two-dimensional turbulent flows" which, despite the idealization leads to results that correlate well with experimental data. Aspects that will be discussed in this presentation include (i) flame topology, (ii) scaling laws for the turbulent flame speed, (iii) the influence of the Darrieus-Landau instability on the turbulent flame, (iv) relation of the predictions to experimental observations.

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Ivan Marusic is a Redmond Barry Distinguished Professor and the Deputy Dean Research in the Melbourne School of Engineering at the University of Melbourne. He received his PhD in 1992 and BE (Hons) Mech in 1987 from the University of Melbourne. From 1998-2006 he was a faculty member at the University of Minnesota in the Department of Aerospace Engineering and Mechanics, and returned to Australia at the end of 2006. His research is primarily in experimental and theoretical studies of turbulence at high Reynolds numbers. This includes studies in atmospheric surface layer flows and aquatic ecosystems. Over his career he has held a number of prestigious fellowships, including an Australian Research Council (ARC) Laureate Fellowship (2012-2017), ARC Federation Fellowship (2006-2011), and a Packard Fellowship in Science and Engineering (2001-2006).

He is a recipient of a number of awards including an NSF Career Award, Woodward Medal at the University of Melbourne, the Stanley Corrsin Award from the American Physical Society, and he is a Fellow of the American Physical Society and the Australasian Fluid Mechanics Society. In 2014 he was elected as a Fellow of the Australian Academy of Science.

Professor Marusic has been an Associate Editor of the *Journal of Fluid Mechanics* since 2008, and generally covers topics related to turbulence, boundary layers, free-shear flows, vortex dynamics and experimental methods.

ABSTRACT

Title: High Reynolds number wall turbulence: Universality, structure and interactions

A key consideration in the characterization of the mechanics of turbulent flows is to understand the generation, evolution and interactions of the large-scale structures and the range of eddying motions that make up the turbulent flow. The non-linearity of these processes makes the problem very challenging, both computationally and experimentally. This is particularly true in wall-bounded flows where an increasing hierarchy of energy-containing eddy scales exists with increasing Reynolds number.

In this talk we will review recent studies by our group in high Reynolds number flow facilities and from the atmospheric surface layer documenting unique high Reynolds number phenomena in wall turbulence. The focus will be the logarithmic region, looking at issues regarding its universality, coherent structures and how they interact across the boundary layer. These findings lead to a new consideration of so-called "inner-outer" interactions and form the basis of a predictive model for the near-wall inner region and the wall-shear stress. The implications of this model will be discussed.

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Amit Agrawal joined Indian Institute of Technology (IIT) Bombay in 2004 and is currently Institute Chair Professor in the Department of Mechanical Engineering. He obtained BTech from IIT Kanpur and PhD from the University of Delaware, USA. He has worked as Engineer in Tata Motors, Pune and as a Postdoctoral Fellow at the University of Newcastle, Australia. His research interests are in micro-scale flows, turbulent flows and convective heat transfer. He has published more than 130 journal articles on these and related subjects, and filed 10 patents. His work has appeared on the cover page of *Journal of Fluid Mechanics* and *JM3* (SPIE *Journal of Micro/ Nanolithography, MEMS, and MOEMS*); and highlighted in the media. He is on the Editorial Board of *Experimental Thermal and Fluid Science*, Nature *Scientific Reports* and *Sadhana*. He is Fellow of Indian National Academy of Engineering and National Academy of Sciences India. He was awarded the DAE-SRC Outstanding Investigator Award and Professor K.N. Seetharamu Medal by the Indian Society of Heat and Mass Transfer.

Professor Agrawal has developed several innovative microdevices (notably, blood plasma separation microdevice; Three-dimensional hydrodynamic focusing microdevice; Constant wall temperature microdevice; Micropump). Embryyo Bio-Microdevices Pvt. Ltd., a Pune-based startup, is developing several novel diagnostic and therapeutic products based on these technologies. Professor Agrawal has also made significant contributions on derivation and application of higher-order continuum transport equations.

ABSTRACT

Title: Search for higher-order continuum transport equations

There is evidence in the literature as well as experimental data from our lab suggesting that the Navier-Stokes-Fourier equations are inadequate to explain several observations with low-pressure gas flows. There seems to be no satisfactory alternative to theoretically describe the flow when the mean free path of the gas is of the order of the characteristic length scale. The two well established approaches of solving the Boltzmann equation yields the Burnett and Grad 13-moments equations. However, several shortcomings of these equations are known by now. This motivated us to explore alternate ways to derive higher-order continuum transport equations.

In this context, we have employed a phase density function consistent with the principles of nonequilibrium thermodynamics and satisfying collision invariance properties, to derive new set of generalized transport equations. The phase density function satisfies the linearized Boltzmann equation and provides the correct value of the Prandtl number for monatomic gas. We term these new equations OBurnett and O13 equations ('O' for Onsager, as these equations are consistent with Onsager's symmetry principle).

The proposed OBurnett equation involve cross single derivatives of field variables such as temperature and velocity, with no higher-order derivative in higher-order terms. This is remarkable feature of the equations as the number of boundary conditions required is the same as needed for conventional Navier-Stokes equations. Linear stability analysis of the OBurnett equations is performed, which shows that the derived equations are unconditionally stable. Similarly, it is noted that the proposed O13 equations require same number of boundary conditions as compared to the Grad equations, and fewer than the regularized 13-moment equations. The Knudsen number envelope which can be covered to describe flows with these equations is expected to be much larger as compared to the earlier equations.
In this talk, I will present these newly derived equations and our current efforts in verifying these equations. The results from the OBurnett equations have been verified for force-driven compressible plane Poiseuille flow problem. I will also present the first analytical solution of the Burnett equations for any configuration. I will also point out the relation between Grad and Cattenao equations (a popular non-Fourier model).

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Partha S. Goswami is holding the position of Assistant Professor in the Department of Chemical Engineering, Indian Institute of Technology, Bombay. Dr. Partha obtained his doctoral from the Department of Chemical Engineering, Indian Institute of Science, Bangalore. He completed his Masters in Technology from Indian Institute of Technology, Kanpur and awarded with Gold medal for best masters thesis. After completion of his doctoral he worked as a Scientist at CSIR-Center for Mathematical Modeling and Computer Simulations, Bangalore for three years. In the year 2012, Dr. Partha joined IIT Bombay as an Assistant Professor. His areas of interest are, particulate flows, turbulent suspensions, fluid bed coating processes etc. Dr. Partha's group is engaged in understanding fundamental aspects of fluid mechanics as well as addressing engineering problems through theoretical, numerical and experimental tools.

ABSTRACT

Title: Dynamics of rough particles in particle-laden turbulent shear flow: Fluctuating force model

Particle-laden turbulent flows find application in wide range of industrial and natural processes, like fluidized bed reactors, pneumatic conveying of solids in chemical and pharmaceutical industries, drying operations, formation of aerosols and motion of pollutants in air and ocean. Though the advent of fast computing facility has enabled investigation of such flows through direct numerical simulation but still simulating flow in case of practically applicable geometry is still far from the reality. Therefore modeling such flows are inevitable. Fluctuating Force Simulation is such a modeling methodology where the effect of fluid velocity fluctuations on the particle is modeled as anisotropic Gaussian White Noise. For dilute suspensions, strength of the noise is extracted from diffusivity data of unladen fluid phase. In the Fluctuating Force Simulation, the inter-particle and wall-particle collisions were assumed to be perfectly smooth and elastic. Such an assumption is oversimplified. Here a more generalized collision rules are developed introducing co-efficient of restitution and roughness factor in hard-sphere collision. Due to the introduction of roughness, rotational motion of the particles starts to play important role on the overall dynamics. Consequently a torque coupling between fluid and particle phase becomes unavoidable. The fluctuations in turbulent fluid vorticity result in fluctuating torque acting on particles. Here in addition to the fluctuating force, a fluctuating Torque also has been included in Langevin type equation to describe the particle motion. Simulations were performed in horizontal turbulent couette flow in case of dilute suspensions for different roughness factor in the limit of high Stokes number. The results obtained are compared with Direct Numerical Simulation (DNS) using one-way coupling.

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Prof. Janani Srree Murallidharan has recently joined as Assistant Professor at the Mechanical Engineering Department at IIT Bombay. She has completed her Ph.D. in Mechanical Engineering from Indian Institute of Technology, Madras. Prior to this, she has done her B.E. in Mechanical Engineering from Hindustan College of Engineering, Anna University-India, followed by a M.E. in Aerospace Engineering at Iowa State University. From January 2013, for a period of 6 months, she was a visiting researcher in the Mechanical Engineering Department at Imperial College London, continuing to work there as a research assistant in their Nuclear Engineering Group until December 2015. Here she was involved in fundamental research on boiling heat transfer. She was also involved in the Indo-UK governments' collaboration projects between Imperial College and Bhabha Atomic Research Centre (BARC).

Both at IIT Madras and at Imperial College London she has been part of several Mulitphase Heat Transfer and Nuclear Energy based research projects. These projects were done in collaboration with leading industry partners and research labs such as Nissan, NPCIL, BHEL, Paul Scherrer Institute (the largest ETH research lab for natural and engineering sciences in Switzerland), as well as with CD-Adapco Multiphase CFD solver development group. While at Imperial College London, she also had the opportunity to collaborate and work under the mentorship of world-renowned experts in the research domains of CFD, Multiphase Flows and Nuclear Energy.

Dr. Murallidharan specializes in the areas of computational fluid dynamics, multiphase flow and heat transfer, nuclear reactor thermal hydraulics, and phase change phenomenon. Her current research interests are in the areas of high pressure boiling, rod bundle heat transfer, Pool Scrubbing, DNS simulations of wall boiling, and bubble contact line dynamics.

ABSTRACT

Title: Computational investigation and mechanistic modeling of subcooled flow boiling for nuclear engineering applications

The perennial demand for energy resources necessitates the need for more efficient means of energy extraction. In this context, subcooled flow boiling is a highly desired form of heat transfer in several industrial systems, since it is the most effective way to achieve high rates of heat transfer at relatively low wall superheats. However, this phenomenon has the potential to quickly transform and trigger critical safety concerns such as in nuclear reactors. This crisis phenomenon, known as 'critical heat flux', can lead to degradation in the nuclear fuel element, eventually leading to its rupture. Due to the central role of subcooled flow boiling, both in efficient heat generation as well as in such crisis events, a detailed study of the phenomenon assumes significance.

Subcooled flow boiling occurs in the immediate vicinity of the heated rod surface where locally the temperature of the water exceeds its boiling point. A large portion of the phenomenon is governed by the bubble dynamics near the wall. Hence, in order to understand subcooled flow boiling, constituent phenomena such as bubble generation at the wall, their movement into the bulk, their distribution and interaction effects, bubble-induced turbulence etc. must be studied. Numerous experimental correlations have been developed which model these constituent phenomena. However, these correlations are limited by their range of applicability. Indeed, these correlations exist only due to our inability to capture the physics of this complex phenomenon, which is spread across many length scales (from nanoscale to component-scale), in its entirety. It is towards filling these lacunae that numerical techniques prove highly useful.

My work focuses on using computational modeling techniques, which span across a wide range of length scales, to develop models that capture the physics of subcooled flow boiling accurately. The goal is to develop a model that generates physically accurate predictions for an extensive range of conditions: for low-high pressures, in pool as well as flow boiling conditions, in low as well as high subcooling, under both horizontal and vertical test section orientation etc. These models are also formulated such that they can be implemented in the component–scale CFD techniques, and thus can help in predicting subcooled flow boiling in nuclear reactors more accurately.

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Vineeth Nair completed his Bachelor's, Master's and PhD in Aerospace Engineering at the Indian Institute of Technology Madras. He was conferred the best thesis award for his dissertation on identifying, modelling and characterizing the intermittency route to combustion instability in 2014. At the institute, he also developed several early warning measures to forewarn combustion instability, flutter in airfoils, and whistling in pipe-flows. Six patents were filed on the subject both nationally and internationally for which he was awarded the J C Bose patent award at IIT Madras.

After his PhD, Dr. Nair was awarded the fellowship for post-doctoral research at the Linne Flow Centre at the KTH Royal Institute of Technology, Stockholm where he worked on identifying precursors to surge in turbochargers and developing vortex detection algorithms using the framework of Lagrangian Coherent Structures (LCS). Dr. Nair joined the Indian Institute of Technology Bombay (IIT Bombay) as faculty in January 2016.

Dr. Nair's interests lie primarily in the field of flow-induced, large-amplitude oscillations. He is also interested in developing general nonlinear frameworks to describe the universal features underlying flow-induced transitions to oscillations. His group at IIT Bombay is utilizing the vortex detection algorithms that he developed to identify structures responsible for sound in a flow-field during the intermittent regime in combustors, which often presage the regime of combustion instability. He is also working towards understanding the routes to instability in two-inhibitor systems commonly found in segmented solid rocket motors.

ABSTRACT

Title: Intermittency as a transition route to combustion instability

Unsteady combustion in a confined, compressible flow-field can lead to the spontaneous excitation of self-sustained periodic oscillations, provided the heat release rate fluctuations are in phase with the pressure fluctuations inside the confinement. These periodic oscillations termed 'combustion instability' or 'thermoacoustic instability' remain a major cause of concern in industrial applications as diverse as household burners which are used for cooking and heating, gas turbine engines used for propulsion and power generation, as well as rocket engines used for space exploration and defense applications. A description of the mechanism underlying the inception of such self-sustained oscillations in combustors remains difficult even after decades of active research as the dynamics involve a complex nonlinear interplay amongst the hydrodynamic, acoustic and combustion processes.

The first part of the talk describes the route through which combustion instability is established from stable operating conditions, when the underlying flow field inside the combustion chamber is turbulent based on experiments performed in two combustor configurations—a swirl-stabilized combustor and a bluff-body stabilized combustor. Our studies indicate that combustion instability is presaged by an intermittent regime characterized by bursts of high-amplitude periodic oscillations that appear in a near random manner from a background of low-amplitude chaotic fluctuations.

The final part of the talk describes techniques to identify and isolate sound-producing structures in the intermittent regime in order to effect passive control strategies at the early design stages of combustors. Experiments were performed on the aforementioned combustors in the regime of intermittent burst oscillations. To understand the role of the flow-field in sound production at these dominant modes, we employ a novel strategy by first decomposing the flow-field using a variant of the dynamic mode decomposition (DMD) and then extracting the backward-time Lagrangian Coherent Structures (LCS) in the decomposed flow-field through the Finite Time Lyapunov Exponent (FTLE) framework. This novel strategy helps us isolate the dynamics at a particular frequency and understand the evolution of the critical dynamics modes as a function of time using the LCS methodology.

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Krishnendu Sinha received his Bachelor of Technology in Aerospace Engineering from Indian Institute of Technology Kanpur in 1995. He went on to do a Master of Science and Ph.D. at the University of Minnesota, USA. His doctoral thesis was in the area computational fluid dynamics, with a focus on simulating turbulent flows in high-speed aerospace applications. After post-doctoral work in the USA, he joined Indian Institute of Technology Madras as an Assistant Professor in 2005. He is currently a Professor in the Department of Aerospace Engineering at the Indian Institute of Technology Bombay.

Over the last ten years, Prof. Krishnendu Sinha has worked in the area of modeling and simulation of high-speed turbulent flows. His research interests include hypersonic flows in general, with particular emphasis on aero-thermodynamics of aerospace vehicles and engine components. His research encompasses shock waves, turbulence modeling, high-temperature gas dynamics, non-equilibrium thermo-chemistry, instability and transition in high-speed flows, and high-performance computing. His work in turbulence modeling has been widely cited and turbulence models developed at IIT Bombay have found application in research laboratories across the world.

The Hypersonic CFD lab at IIT Bombay, headed by Prof. Sinha, has a very active group of Ph.D. students working on a wide variety of aerospace applications, from re-entry flows to scramjet engines. The work in re-entry flows is aimed at afterbody aero-heating, where in-house CFD codes are validated against experimental data and flight measurements. His research group has also done extensive simulation of hypersonic intakes for scramjet application and of rocket nozzle exhaust jets.

ABSTRACT

Title: Shock-turbulence interaction: Theoretical analysis and turbulence modeling for aerospace application

Shock waves and turbulence together make an interesting area of research. Shock waves are discontinuities in high-speed flows, which can result in extremely high pressure and temperature. A turbulent flow passing through a shock wave exhibit a range of physical phenomena. These include, enhanced mixing, generation of acoustic energy, high degree of turbulence anisotropy, to name a few. Shock-turbulence interaction is also practically very relevant to high-speed flight and air-breathing propulsion systems. It plays crucial role in applications like supersonic combustion in scramjet engines and unstart of hypersonic intakes. The crux of the problem is to predict the turbulent amplification across the shock, which directly determines key phenomena like boundary layer separation/reattachment and high heat transfer in the vicinity of shock waves.

The canonical problem of homogeneous isotropic turbulence passing through a normal shock wave is possibly the simplest and the most fundamental problem. It brings out many key aspects of shock-turbulence interaction, like the unsteady shock oscillations, baroclinic generation of vorticity and high thermodynamic fluctuations behind the shock wave. Canonical shock-turbulence interaction is amenable to an elegant theoretical analysis based on linearized governing equations and a separation of scales between the shock wave and the turbulent fluctuations. The problem is also studied using large-scale direct numerical simulations, which include non-linear and viscous effects neglected in the theoretical analysis. However, DNS poses significant numerical challenges to capture the shock wave without dissipating the turbulent fluctuations, and stretches the limits of current computational resources.

We use a combination of theoretical and computations simulations to perform extensive studies of canonical shock-turbulence interaction. The dominant physics are identified for varying Mach number, Reynolds number and for different types of turbulent fluctuations in the incoming flow. Of particular interest is the amplification of turbulent kinetic energy, which governs separation and reattachment of turbulent boundary layers interacting with shock waves. The peak turbulent heat flux behind a shock is also important, as it can result in very high heat transfer to the vehicle surface. Our studies over the past several years have identified a number of interesting physics at shock waves. Insights obtained from DNS and theoretical analysis are used to develop turbulence models for CFD simulation. Application to shock-boundary layer interaction flows have shown marked improvement in predicting flow separation and peak heat transfer rates accurately. The new turbulence models have also been applied to real-life configurations in aerospace vehicles.

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Rochish Thaokar received his B.Tech from LIT, Nagpur in 1995 and M.E (1997) and PhD (2003), all in chemical engineering, from IISc, Bangalore. This was followed by a Post doctoral stint at the Max Planck Institute for Polymerforschung, (MPIP) Mainz, Germany in polymer physics. He worked as a scientist for a year in TRDDC, Pune, then joined the Indian Institute of Technology Bombay (IITB), department of chemical engineering as an Assistant Professor in February 2005. He was promoted to Associate Professor in 2011, and Professor in 2015.

Rochish's PhD work addressed hydrodynamic instabilities arising from the interaction between Newtonian fluid flow and soft solids. In MPIP-Mainz, he pursued research in polymer physics with Professor Helmut Schiessel in the group of Professor Kurt Kremer. In IITB, Rochish has pursued several research areas. Prominent amongst them were boundary element calculations of self propelled tori and describing Brownian tori. He also addressed experimental and theoretical issues in electrohydrodynamic patterning of substrates with soft materials, unravelling the role of various time scales and judicious use of AC electric fields to realise leaky or perfect dielectric behaviour.

Currently, Rochish predominantly looks at electrohydrodynamics of drops and of vesicles, cells and capsules. In drops, he focusses on electro-deformation, breakup, and emulsification to understand the fundamentals of electrohydrodynamics. He also works in the area of electro-coalescence with applications in the refinery industry and electrodynamic levitation to understand the fundamentals of Rayleigh breakup of a charged droplet.

ABSTRACT

Title: Electrohydrodynamics of drops in AC/DC, low/high, Uniform/non-Uniform electric fields

Electric field has emerged as a promising tool to induce electric stresses that can overcome interfacial resistance in drops, capsules, biological cells and vesicles, leading to their deformation, rupture, fusion, pore formation etc. An attractive feature of electric fields is the variety of parameters it offers to modulate these forces such as spatio-temporal variation (AC-DC and uniform-non-uniform) as well as intensity of the electric field. An important advantage of electric field, is its minimally invasive character, thereby providing a nearly non-contact way of modifying soft materials. In this presentation an over view of these aspects will be provided and a detailed study of drop deformation in strong fields will be addressed.

A conducting drop suspended in a viscous dielectric and subjected to a uniform DC electric field deforms to a steady-state shape when the electric stress and the viscous stress balance. Beyond a critical electric capillary number *Ca*, which is the ratio of the electric to the capillary stress, a drop undergoes breakup. Although the steady-state deformation is independent of the viscosity ratio λ of the drop and the medium phase, the breakup itself is dependent upon λ and *Ca*. A detailed experimental study using high speed imaging and numerical analysis using the boundary integral method, of axisymmetric shape prior to breakup (ASPB), and non-axisymmetric shape at breakup (NASB) are described. It is found that the lobes, pointed ends and non-pointed ends observed in ASPB give way to NASB modes of charged lobes disintegration, regular jets (which can undergo a whipping instability) and open jets, respectively.

The breakup of a single or few drops under strong electric fields, ultimately leads to formation of an emulsion with very fine size that is decided by the interaction of the charged droplets with the electrode. This interaction also results in several interesting phenomena such as chain formation, bouncing of drops etc.

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Gunjan Hajela is the Marketing Lead for Academic Business in India/South Asia with more than 10 years of experience in Marketing, Customer Engagement, Sales and Business Development. He joined the Press in November 2016. Previously he spent more than six years working with Elsevier. He is post graduate in Marketing and Human Resources and has also done an executive management development program from Indian Institute of Management, Calcutta.

ABSTRACT
Title: Cambridge Core review
Gunjan will be talking about the new academic platform for Cambridge University Press – Cambridge Core – and will showcase the content on offer. He will give a background of Core's development. He will also demonstrate its features and functionalities both from the perspective of librarians and researchers.

KATHLEEN TOO
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Kathleen Too is currently the Publisher for Mathematical and Physical Sciences Journals at Cambridge University Press. She is currently responsible for over 50 journals at CUP covering Mathematics, Computer Science, Earth Sciences, Physics, Engineering and Astronomy. She has 10 years' experience in managing existing journals and launching new journals. She worked as an Assistant Editor and then a Deputy Editor at the Royal Society of Chemistry. In 2013, she became the International Development Manager for Asia, helping the Royal Society of Chemistry to reach out to emerging markets in Asia. She graduated from the University of Leeds where she did her BSc and PhD and she did a postdoc at the Medical Research Council, Lab of Molecular Biology in Cambridge UK.

ABSTRACT
Title: Publishing workshop
In this workshop, aimed at early career researchers, we'll discuss the nuts and bolts of publishing your research. How should you choose which journal to submit to? How do you approach a publisher if you have an idea for a book? What do editors consider when assessing your work for publication? How does peer review work behind the scenes, and how should you respond to peer reviewers? Come along to find out the answers to these questions and many more, followed by an interactive discussion.

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