JFM Symposia:

From Fundamentals to Applied Fluid Mechanics

SPEAKER BIOGRAPHIES
AND ABSTRACTS

14-15 DECEMBER
IIT, CHENNAI

Day 1 - Publishing Workshop
Day 2 - JFM Symposium

Indian Institute of Technology Madras

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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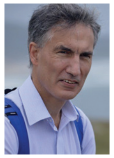
Dear Colleagues,

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 Madras. We would like to give special thanks to our hosts S. Pushpavanam and Mahesh Panchangula, IIT Madras, 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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KATHLEEN TOO
Publisher, Physical Sciences STM
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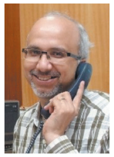
Dear Colleagues,

It gives me great pleasure to welcome you to the JFM India symposium being organised in IIT Madras on December 15th, 2017. We look forward to hosting you in our natural verdant campus in the midst of banyan trees, spotted deer and the black buck.

IIT Madras is one of the first five premier technological institutes of India and was established around 55 years ago. Research in fluid mechanics has brought close collaboration between faculty of chemical engineering, mechanical engineering, applied mechanics, civil engineering, aerospace engineering, metallurgical engineering, mathematics and physics.

With a National Center for Combustion Research, a Center for Propulsion Technologies and a thriving fluid mechanics research community spread over seven academic departments, IIT Madras is a thriving center for fluid dynamics research. We look forward to hosting you at the event, to all the enriching talks and interactions during the symposium and to building strong research collaborations, looking towards the future.

MAHESH PANCHAGNULA
IIT Madras
India



S. PUSHPAVANAM
IIT Madras
India

Workshop with librarians and students

14 December 2017

Time	Lecture
15:30-16:15	Awareness workshop on Cambridge Core **Gunjan Hajela, *Cambridge University Press***
16.15-17:15	Publishing workshop **Kathleen Too, *Cambridge University Press***
17.15-17.45	Discussions and coffee break

15 December 2017

Time	Lecture	Chair
09.00-09.30	Opening speech from Cambridge University Press **Kathleen Too, *Cambridge University Press*** Opening speech from IIT Madras **S. Pushpavanam, *IIT Madras*** **Mahesh Panchangula, *IIT Madras***	**S. Pushpavanam**
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	Onset of transition in the flow of polymer solutions in tubes **V. Shankar, *IIT Kanpur***	
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***	**Grae Worster**
11.30-11:40 **PhD student flash talks**	Interfacial pattern selection in defiance of linear growth (J. R. Picardo and R. Narayanan) **Jason Ryan Picardo, *IIT Madras***	
11:40-11:50 **PhD student flash talks**	Agent based model for coalescence avalanches in microchannels (M. Danny Raj, R. Rengaswamy) **M. Danny Raj, *IIT Madras***	
11:50-12:00 **PhD student flash talks**	Induced mixing in a microchannel using electro-osmosis (T. Krishnaveni and S. Pushpavanam) **T. Krishnaveni, *IIT Madras***	
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***	**Ivan Marusic**
13.30-14.00	Time series analysis of single phase and multiphase turbulent flows **Mahesh Panchangula, *IIT Madras***	
14:00-14:30	Local instabilities in vortices **Manikandan Mathur, *IIT Madras***	
14.30-15.00	Coffee/Tea break	
15.00-15.10 **PhD student sessions**	Size-based migration of a water droplet over a curved mineral oil interface: a compound droplet study (R. Iqbal, S. Dhiman, A. K. Sen, Amy Q. Shen) **Sk Rameez Iqbal, *IIT Madras***	**Mahesh Panchangula**
15:10-15:20 **PhD student sessions**	Linear stability of layered two-phase flows through parallel soft-gel-coated walls (B. Dinesh and S. Pushpavanam) **B. Dinesh, *IIT Madras***	
15:20-15:30 **PhD student sessions**	Simulations of unsteady fuel sprays under high pressure and high temperatures ambient conditions (Anandteerth, T. Sundararajan and S. Sahu) **Anandteerth, *IIT Madras***	
15.30-15.45	What does a JFM Editor look for when assessing a paper? **Grae Worster, *University of Cambridge***	**Kathleen Too**
15.45-16.45	JFM panel discussions **Grae Worster, *University of Cambridge*** **Moshe Matalon, *University of Illinois at Urbana-Champaign*** **Ivan Marusic, *University of Melbourne***	
16.45-17.00	Closing remarks **Grae Worster, *University of Cambridge*** **S. Pushpavanam, *IIT Madras*** **Mahesh Panchangula, *IIT Madras***	

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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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Manikandan Mathur is currently an assistant professor in the department of Aerospace Engineering, Indian Institute of Technology Madras (IIT Madras), Chennai, India. Prior to joining IIT Madras in October 2012, Manikandan spent two years as a postdoctoral researcher in France. As a postdoc, he worked on problems in Geophysical Fluid Dynamics at the Coriolis platform in LEGI, Grenoble, while being funded by projects at ENS de Lyon (Lyon) and Ecole Polytechnique (Palaiseau). Manikandan did his doctoral studies (2005-2010) in the department of Mechanical Engineering at the Massachusetts Institute of Technology, Cambridge, USA, with his PhD thesis on "Laboratory and analytical modelling of internal waves in uniform and non-uniform stratifications". He graduated with a Masters degree in the Engineering Mechanics Unit, Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, India in 2005, after receiving his B. Tech. in Aerospace Engineering, IIT Madras in 2004. His current research interests include experimental fluid mechanics, Lagrangian coherent structures, flow separation & control, internal gravity waves, stability of vortical flows.

ABSTRACT

Title: Local instabilities in vortices

The local stability approach has emerged, in the last few decades, as a powerful tool to investigate short-wavelength instabilities in strongly non-parallel flows. In this talk, I will present an overview of the local stability approach, and its application to a wide range of idealized vortex models. An investigation of centrifugal, elliptic and hyperbolic instabilities in the local stability framework will be presented, and the results will be put in the context of the results known from the classical normal mode approach. The local approach will then be implemented on Stuart vortices, which represent a theoretical model of the vortices that form in the mixing layer. The effects of various factors like the vortex profile, axial flow, background rotation, stratification, and diffusion will then be discussed. Time permitting, the insights gained by performing a local stability analysis on numerically simulated base flows will be presented.

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Mahesh V. Panchagnula graduated from IIT Madras in 1992 with a B. Tech in Mechanical Engineering. He subsequently obtained an MSME in 1994 and Ph.D. in ME in 1997, both from Purdue University. He has since worked in industrial research positions with Goodrich Aerospace and Excel India till 2004. He has served as a Research Fellow at Lehigh University and as an Assistant Professor of Mechanical Engineering at Tennessee Technological University from 2005 to 2010. He has been on the faculty of the Department of Applied Mechanics, Indian Institute of Technology Madras since 2010 and in the current rank since 2014. He is also the faculty advisor to IIT Madras pre-incubator Nirmaan and the associate faculty-in-charge of the IIT Madras Incubation Cell, which advises faculty and students entrepreneurship activities.

Dr. Panchagnula's current research broadly focuses on fundamental interdisciplinary multiphase thermal/fluid phenomena including wetting, hysteresis in natural systems, spray formation physics, pulmonary aerosol transport, liquid-liquid wetting and spray combustion. His lab employs both experimental as well as theoretical inquiry techniques. He has worked on the problem of contact angle hysteresis and shown that it is an effect originating at the contact line. In addition, he has worked on wetting in partially miscible liquid-liquid systems such as oil/water thin film dynamics with Marangoni effects. His recent research has focused on applying simulation and data analytics tools to fluid mechanics problems such as the behavior of large crowds and turbulence. His complete list of published work can be found on Google Scholar.

ABSTRACT

Title: Time series analysis of single phase and multiphase turbulent flows*

* Collaborators: Dr. Sri Vallabha Deevi and Prof. Arun K. Tangirala

Turbulent flows are usually characterized by a continuous time series of velocity, pressure and other variables. Most analyses of turbulent flows rely on the fact that the mean and variance of flow quantities do not change with time, i.e. the flow is stationary. In the time series literature, stationarity has a more rigorous requirement that the joint probability distribution of the observed quantities is invariant in time. We examine the proposition whether fluid mechanics measurements are stationary in this more rigorous sense. We choose experimental measurements from two classes of turbulent flows a) active grid turbulence and b) Phase Doppler Particle Analyzer data on an air blast atomizer spray which includes drop size and velocity time series - for the analysis. Our analysis reveals that these flows are statistically non-stationary due to the presence of heteroskedasticity i.e. variance is a function of time. Interestingly, this phenomenon is observed for both drop size as well as velocity time series.

We next analyze the time series using two techniques - a state transition matrix approach and a (more general) auto-correlation approach. We identify the state of the system by mapping the analog velocity (or drop size) data into discrete states. For example, the drop size "state" may be classified as either *small* (S_1), *medium* (S_2) and *large* (S_3) drops by percentile. We then construct a state transition matrix $\mathbf{A}_{3\times3} = P(x = S_i(t_{n+1})|S_j(t_n))$. This is based on measurements of successive drop sizes to identify the probability of a state change in the observed quantity. This state transition matrix is a measure of persistence in the flow. If $\mathbf{A} = \mathbf{I}$ ($\mathbf{I}$ is the identity matrix), the flow remains in its initial state. In contrast, $\mathbf{A} = \frac{1}{3}\mathbf{J}_3$ (where $\mathbf{J}_3$ is a 3 × 3 unit matrix) points to zero persistence. Using a Frobenius norm, we calculate the relative distance of our experimentally determined A from both $\frac{1}{3}\mathbf{J}_3$ and $\mathbf{I}$. From this analysis, we show that single phase turbulent flows show greater persistence than multiphase flows.

Finally, we study the partial auto-correlation characteristics of the time series signal. This study reveals that velocity shows significant correlation spanning five successive drops. Surprisingly, drop size time series appears to follow a Markov process, implying that a large drop is more likely to be followed by another large drop. This points to a new form of clustering in sprays.

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V. Shankar obtained his undergraduate degree in Electrochemical Engineering at Central Electrochemical Research Institute, Karaikdudi (in 1993), and his Masters and PhD degrees in Chemical Engineering from the Indian Institute of Science, Bangalore (respectively in 1995 and 2000). For his PhD thesis, he worked with Prof. V. Kumaran on linear and weakly nonlinear stability of flow through flexible tubes and channels. He subsequently spent two years for his postdoctoral research at the University of Minnesota, Minneapolis, working with Prof. David Morse on molecular theories for dynamics and rheology of semiflexible polymers. He took up a faculty position at the Department of Chemical Engineering, IIT Kanpur in 2002, where he is now a full Professor and currently the Head of the Department. His research interests are in the areas of hydrodynamic stability in flow past deformable surfaces, instability and transition in viscoelastic flows and dynamics of thin liquid films. His research group uses both theoretical/computational methods and experimental techniques to understand these systems.

ABSTRACT

Title: Onset of transition in the flow of polymer solutions in tubes

Laminar flow of Newtonian fluids in a tube/pipe becomes unstable at a Reynolds number ~2000, but linear stability analysis predicts that the flow is stable at all Reynolds number. However, when flow of viscoelastic polymer solutions are considered, earlier experiments have observed all the three possibilities upon addition of polymer to a Newtonian fluid: no effect, a delay, or an advancement in the Reynolds number for onset of the transition. We carry out experiments to characterize the onset of transition in the flow of polymer solutions microtubes (of diameters 390 and 470 μm). Two different polymer (polyacrylamide and polyethylene oxide) solutions at varying concentrations are considered, and the transition is characterized using micro-PIV measurements as well as dye-stream visualization. By considering tubes of such small diameters, the present experiments probe (hitherto unexplored) regimes of high elasticity number $E = \lambda\nu / R^2$ where λ is the longest relaxation time of the polymer solution, ν is the kinematic viscosity and R is the tube radius. Our results show that for small concentrations of the added polymer, there is a transition delay, but at sufficiently large concentrations, the *Re* for transition can be as low as 800. We show that the data for transition *Re* for solutions of two different polymers of varying polymer concentration, different tube diameters collapse well according to the scaling relation $Re_c \propto (E((1 - \beta))^{-1/2}$ where β is the ratio of solvent to solution viscosity. This talk will also discuss the results from our theoretical efforts based on linear stability analysis and their relevance to experimental observations.

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Interfacial pattern selection in defiance of linear growth

One of oldest paradigms in interfacial pattern formation is that the wavelength with the largest linear growth rate dominates the emergent pattern. It was first propounded by Lord Rayleigh in his study of the capillary instability of jets[1], and has since been applied to a variety of problems, e.g. the Rayleigh-Taylor instability of liquid suspended from a ceiling, and viscous fingering of a water-oil interface[2]. In the present study, we test the limits of this hypothesis, by examining nonlinear pattern selection in a subcritical system that has a linear growth curve (dispersion curve) with two peaks of equal height. Such a situation is exemplified by a physical system consisting of two liquid layers suspended from a heated ceiling and exposed to a passive gas, such that both interfaces are susceptible to thermo-capillary and Rayleigh-Taylor instabilities. We use a combination of numerical simulations, based on long wavelength evolution equations[3], and low-dimensional amplitude equations to trace the nonlinear evolution of the interfacial pattern and understand the subtle interactions between the two peak modes. Surprisingly, we find that one of the peak-modes can completely dominate the other, to the extent that the final interfacial pattern is devoid of any trace of the other peak-mode. Far from being governed by simple linear theory, the final pattern is sensitive even to the phase difference between perturbations to the peak-modes.

Acknowledgment: Support from NASA-CASIS GA-2015-218 and the Fulbright-Nehru fellowship is gratefully acknowledged.

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Agent based model for coalescence avalanches in microchannels

Studying coalescence avalanches in a 2D emulsion flowing through a microchannel is a challenging task. Investigating the problem from a Navier-Stokes front would be computationally demanding due to the non-linear and multi-scale nature of the coalescence process, the large number of deformable droplets in the confined Hele-Shaw flow geometry and the formation and motion of complex shaped clusters due to a series of coalescence events. An experimental method of investigation would be equally daunting because of the huge number of degrees of freedom associated with the system. This is due to the presence of multiple droplets which self-organize resulting in a continuously fluctuating inter-droplet spacing and rates of approach and retraction which makes the process appear stochastic to an observer[1]. Because of this probabilistic nature of the phenomenon, both the above-mentioned methods would have to be repeated enough number of times to extract useful information like the probability of avalanches to predict the stability of an emulsion. Hence there is a need for a novel method to studying such problems. We employ an agent based approach to modelling coalescence avalanches where the idea is to identify and characterize droplet-level interactions using simple models or probabilistic rules, which can be incorporated in a multi-agent formulation to simulate the group-level avalanching phenomena[2]. The computational simplicity of the model allows us to carry out large number of trials and helps us derive insights into the nature of the avalanching process and the stability of the emulsion system. We also show how the model can be used in conjunction with machine learning tools to develop classifiers which can be used in predicting the stability of an emulsion by analysing the droplet configuration online. The simplicity of the model also allows us to generalize the results to a broad range of finite-sized systems where avalanches can propagate and interact[3].

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Induced mixing in a microchannel using electro-osmosis

We propose an innovative mechanism for enhancing mixing in pressure driven flows of an electrolytic solution in a rectangular microchannel. A transverse electric field is used to generate an electroosmotic flow across the cross-section. The resulting flow field consists of a pair of helical vortices that transport fluid elements along the channel. We show that chaotic advection may be induced by applying an electric field whose direction varies periodically along the channel length. This periodic electric field generates a flow which has projected streamlines in one half of the periodic domain intersecting those in the other half. Mixing is qualitatively characterized by tracking passive particles and obtaining Poincare maps. For quantification of the extent of mixing, Shannon entropy is calculated using particle advection of a binary species mixture. The convection diffusion equation is also used to track the evolution of a scalar species and quantify the mixing efficiency as a function of the Peclet number.

Keywords: Microchannel, pressure driven flow, transverse electroosmotic flow, chaotic advection, mixing.

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Size-based migration of a water droplet over a curved mineral oil interface: a compound droplet study

The dynamics of compound droplets with a denser liquid (water) droplet over a less dense sessile droplet (mineral oil) that satisfies the Neumann condition is hereby reported. For a fixed size of an oil droplet, depending on the size of the water droplet, either it attains the axisymmetric position or tends to migrate toward the edge of the oil droplet. For a water droplet-to-oil droplet at volume ratio $V_w/V_o>0.05$ a stable axisymmetric configuration is achieved; for a $V_w/V_o<0.05$ migration of water droplet is observed. The stability and migration of water droplets of size above and below critical size respectively are explained using the force balance at the three-phase contact line and film tension. The larger and smaller droplets that initially attain the axisymmetric position or some radial position respectively evaporate continuously and thus migrate towards the edge of the oil droplet. The radial location and migration of the water droplets of different initial size with time are studied. Experiments with water droplets on a flat oil-air interface did not show migration, which signified the role of the curved oil-air interface for droplet migration. Finally, coalescence of water droplets of size above the critical size at the axisymmetric position is demonstrated. Migration and coalescence of water droplets on curved oil-air interfaces could open new frontiers in chemical and biological applications including multiphase processing and biological interaction of cells and atmospheric chemistry.

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Linear stability of layered two-phase flows through parallel soft-gel-coated walls

The linear stability of layered two-phase Poiseuille flows through soft-gel-coated parallel walls is studied in this work. The focus is on determining the effect of the elasto-hydrodynamic coupling between the fluids and the soft-gel layers on the different instabilities observed in flows between parallel plates. The fluids are assumed Newtonian and incompressible, while the soft gels are modelled as linear viscoelastic solids. A long-wave asymptotic analysis is used to obtain an analytical expression for the growth rate of the disturbances. A Chebyshev collocation method is used to numerically solve the general linearized equations. Three distinct instability modes are identified in the flow: (a) a liquid-liquid long-wave mode; (b) a liquid-liquid short-wave mode; (c) a gel-liquid short-wave mode. The effect of deformability of the soft gels on these three modes is analysed. From the long-wave analysis of the liquid-liquid mode a stability map is obtained, in which four different regions are clearly demarcated. It is shown that introducing a gel layer near the more viscous fluid has a predominantly stabilizing effect on this mode seen in flows between rigid plates. For parameters where this mode is stable for flow between rigid plates, introducing a gel layer near the less viscous and thinner fluid has a predominantly destabilizing effect. The liquid-liquid short-wave mode is destabilized by the introduction of soft-gel layers. Additional instability modes at the gel-liquid interfaces induced by the deformability of the soft-gel layers are identified. We show that these can be controlled by varying the thickness of the gel layers. Insights into the physical mechanism driving different instabilities are obtained using an energy budget analysis.

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Simulations of unsteady fuel sprays under high pressure and high temperatures ambient conditions

The present work focuses on the numerical analysis of the dispersion and evaporation of spray droplets injected from a high-pressure swirl atomizer into a high-pressure and high-temperature ambient environment relevant to Gasoline Direct Injection in automotive applications. The gas phase is modelled by the Eulerian RNG k-ϵ model in conjunction with the Lagrangian Discrete Phase Model (DPM) for tracking spray droplets. The mass, momentum and energy coupling between the droplet and the gas phases are accounted by appropriately modelling the source terms in the gas phase equations. The primary breakup of liquid sheet was modelled based on the LISA model. The spray simulations were carried out for the same operating conditions for which experimental data are available. The spray simulations are found to be sensitive to the choice of the models for the secondary atomization and collision of droplets. The residual liquid mass, before the injection of the main spray, known as the pre-spray was also accounted in the simulations. In general, the time evolution trends of the overall spray structure, the penetration length and average droplet size predicted by the spray simulation are found to be in good agreement with the experiments. However, the penetration length is underestimated by about 35%. Though, the average size is overestimated in the simulations, switching off the collision model after the duration of fuel injection improves the size prediction.

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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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