

International Conference on Flow Visualisation and Imaging Techniques

(ICFVIT 2026)

Book of Abstracts

Conference Date: 13–15th February, 2026

Venue: ICSR



Indian Institute of Technology Madras
Chennai-600036

Contents

Invited Talks	4
1. Thoroddsen S.T. – Drop-impact ejecta splashing via high-speed color interferometry	4
2. Muralidhar K. – Imaging a Deforming Gas-Liquid Interface For Building Contact Angle Models	4
3. Sciacchitano A. – 10 Years of the Ring of Fire: Quantitative Flow Visualization for Transiting Objects	5
4. Tropea C. – Depth from Defocus Measurement Technique: Quo Vadis?	5
5. Srivastava A. – Advanced diagnostics for simultaneous mapping of transport phenomena and interfacial dynamics during droplet impact	6
6. Tiwari N. – Data assimilation in flow visualization	7
7. Fond B. – Fluid thermometry using inorganic phosphor tracer particles	7
8. Kumar A. – The yoga of droplets: coalescence in complex fluids	8
9. Basu S. – Adventures of a Droplet: A Multiscale Journey to Extreme Flow Conditions	8
10. Sahu S. – A multi-directional imaging technique for liquid jet core visualization in airblast injectors	8
11. Cheverda S. – The heat transfer in the liquid drop contact line	9
12. Odier P. – Generating, observing and characterizing internal gravity waves in stratified media	10
13. Tambe S. – Coherent and intermittent flow structures in three-dimensional boundary layer transition	10
Contributed Talks	12
1. Shahdhaar M. – Dual-wavelength interferometric measurements of temperature and concentration fields of a volatile droplet impacting a solid surface	12
2. Priyanka P. – Taylor bubble rise through shear-thinning liquids in closed top inclined tubes	12
3. Goswami S. – Estimation of Inertial Fog Droplet Capture on Cylindrical Fibers using Digital Inline Holography	13
4. Prakash J. – Experimental Study of Falling Films over Horizontal Tubes Using Digital Holographic Interferometry	13
5. Balasubramani S. – Data-Driven Prediction of Fuel Spray Dynamics using a Novel Hybrid Machine Learning Technique	14
6. Pawar S. – Mixed-Convection Free-Shear Flow Through Porous Screens	15
7. Shaik N. – Pore-Scale Visualization of Multiphase Flow in Enhanced Oil Recovery Using a PDMS Microchannel	15
8. Abhilash M.S. – Direct Adhesion Force Characterization on Superhydrophobic and Patterned Surfaces Using Cantilever Deflection	16
9. Singh A. – Flow-field and Acoustic Characterization of an Actively Controlled Mach 0.5 Jet	17
10. Chimurkar D. – Evaluation of agglomerate particle size distribution in aluminized RDX based AP/HTPB composite propellant flames through image analysis	17
11. Xavier A. – Stabilizing Microfluidic Droplet Imaging Using a CD-Drive-Based Microstepping Linear Actuator	18
12. Padmanaban M. – Dynamics of Elongated Taylor Bubbles in non-Newtonian Fluids	19
13. Mugundhan V. – Coherent Structures in a Turbulent Jet	20

14. Loganathan D. – Reconfigurable Microfluidics Using Multiple Magnetic Micro-robots	20
15. Revathy R.K. – Shock-Dominated Flow Features in Supersonic Rectangular Impinging Jets	21
16. Keshav V. – Liquid-in-liquid encapsulation during immiscible drop-pool impact	21
17. Dharmarajan K.R. – Spiky contacts during the impact of an emulsion drop on a solid surface	22
18. Veerapandiyan K. – Visualizing Viscous Dissipation in Vertical Planetary Mixer	22
19. Mohd J. – Development of Tomographic Background-Oriented Schlieren for 3D density measurement in buoyant plumes	23
20. Raghavendra S. – Drop shape and velocity field in drop splash	23
21. Bhat A. – Investigation of Dense Particulate Suspensions in Stirred Tanks by Real-Time X-ray Radiography Technique	24
22. Kumar P. – Chaos in Stokes Flows enhances stirring	25
23. Prabhudeva P. – Comparative Experimental Investigation of Spray Characteristics of Boron-Loaded Slurry and Gel Fuels	25
Selected Poster Presentations	27

Abstracts of Invited Talks

Invited Talk 1

Drop-impact ejecta splashing studied via high-speed color interferometry

S.T. Thoroddsen, D. Krishna Raja
KAUST, Saudi Arabia

The splashing from raindrops impacting the ocean surface is an important source of aerosols. The finest spray droplets evaporate to leave crystallized solutes, which are easily airborne. Understanding the origin of the smallest splashed droplets is therefore of interest. The ejecta sheet which rapidly emerges from the neck connecting the impacting drop to the pool is a source of fast-moving tiny droplets [1]. Initially propagating nearly horizontally, the sheet can then bend and stretch into intricate curved shapes [2]. We investigate the evolution of its shape and thickness using high-speed three-color transmissive interferometry, as shown in Figure 1. To pin down the absolute sheet thickness, we compare the fringe patterns formed by the three distinct wavelengths, using LED lights with narrow bandpass filters. Experiments are conducted over a range of liquid viscosities, using water-glycerin mixtures, up to 210 cP. The $D = 6.3\text{mm}$ drops are impacted at velocities between 1 to 6m/s, to map the ejecta regimes. For viscosities above 8cP, the ejecta sheet exhibits pronounced radial and axial stretching, often entrapping an air torus, taller than the drop, as is shown in the Figure. These measurements allow us to track the relative strength of the forces counteracting the impact inertia, i.e. those of air resistance, viscous stress, and surface tension.

References:

- [1] S.T. Thoroddsen, J. Fluid Mech. 451, 373-381 (2002).
- [2] Y.S. Tian et al., J. Fluid Mech. 981, A4 (2024).

Invited Talk 2

Imaging a Deforming Gas-Liquid Interface For Building Contact Angle Models

K. Muralidhar
IIT Kanpur, India

In a modeling framework of gas-liquid flows, the governing equations of mass, momentum, and interfacial tension can be readily established. The point of difficulty is the three-phase contact line where the liquid phase slides over the partially wetting surface and violates the no-slip condition. In a continuum framework, closure is attained by specifying the time-dependent contact angle as a function of the contact line velocity. Developing a general-purpose contact angle model for wettability, applicable for all liquids and surface textures, has been the goal of research in the last decade. Wettability is often prescribed in terms of an equilibrium contact angle and hysteresis, although the inadequacy of this modeling approach is well-known when liquid droplets interact with textured substrates. With improvements in camera speed and resolution, it is possible to record high-speed image sequences and estimate parameters of contact

angle models that include temporal effects. A single liquid drop spreading over a flat surface displays a wide variety of flow characteristics, including oscillations, bounce-off, pinning, and final equilibrium, depending on the interfacial and thermophysical properties of the liquid phase and, more importantly, the surface texture. The present work shows that, starting from quiescent conditions, a drop spreading experiment with high-speed imaging can be used to calibrate the contact angle model of a surface. The dynamic contact angle model, recently proposed by the authors, incorporates friction and pinning of the contact line motion. The model, calibrated against drop spreading data, is subsequently tested for drop impact, coalescence, electrowetting, and drop spreading over pillared surfaces. The data arising from simulations are compared against experiments. In a wide range of contexts, the proposed dynamic contact angle model is seen to predict the time-resolved interface shapes reasonably well.

Invited Talk 3

10 Years of the Ring of Fire: Quantitative Flow Visualization for Transiting Objects

A. Sciacchitano

Delft University of Technology, Netherlands

Although Particle Image Velocimetry (PIV) is the chief technique for the quantitative visualization of fluid flows, its application has been long confined to the lab environment and relatively small scales. Over the past 10 years, my team has developed a novel concept, the Ring of Fire, which allows for the quantitative flow visualization around transiting objects of cubic-meter size. The key ingredients of the Ring of Fire are: sub-millimetre Helium-Filled Soap Bubbles as flow tracers; LED or laser illumination; an object transiting through the measurement domain; multiple high-speed cameras to record the motion of the tracer particles; the application of the conservation of momentum in a control volume to retrieve the aerodynamic drag acting on the object. In this talk, I will discuss the development of the Ring of Fire concept, starting from the proof of concept measurements of the flow around a transiting sphere, and its applications in the realm of sports aerodynamics (cycling and running) and automotive. An outlook on the future perspectives of the technique will be provided.

Invited Talk 4

Depth from Defocus Measurement Technique: Quo Vadis?

Cameron Tropea

Technical University of Darmstadt, Germany

The depth from defocus (DFD) measurement technique has undergone rapid advancements over the last decade, enabling the size and position (depth) of backlit spherical particles within a three-dimensional volume to be determined with very high accuracy. This not only represents a single-camera particle tracking capability, but also allows number/volume density in dispersed, two-phase flows to be measured, a unique feature compared to other particle sizing techniques. In this lecture, the basic principles of DFD will be briefly reviewed, followed by

a discussion of achievable measurement limits in terms of effective depth of field, size ranges, and limiting number/volume densities. These limitations are discussed on the one hand for analytical processing schemes, on the other hand for convolutional neural networks. Two future directions will be reviewed: extension of DFD to non-spherical, or irregularly shaped particles; and extension to the simultaneous measurement of particle temperature using phosphorescent lifetime.

Invited Talk 5

Advanced diagnostics for simultaneous mapping of transport phenomena and interfacial dynamics during droplet impact

Atul Srivastava
IIT Bombay, India

Droplet impact on liquid pools and solid surfaces has been of interest due to its ubiquity in nature and wide range of engineering applications. Such impacts involve a range of transient interfacial transport phenomena that are challenging to visualize due to their rapid evolution and strong coupling between hydrodynamics, mass transfer, and heat transfer [1,2]. Experimental studies exploring these processes have employed a variety of complementary flow diagnostics to investigate the involved spatio-temporal dynamics and their resulting transport behavior across different configurations [2,3]. Within this broader context of droplet impact visualization, optical techniques that enable whole-field access to interfacial dynamics are particularly crucial for resolving post-impact surface behavior. In this regard, the interfacial deformations following droplet impact on liquid pools are examined using background-oriented schlieren (BOS). BOS enables whole-field, non-intrusive visualization of surface perturbations and capillary waves generated after impact for both miscible and immiscible droplet-pool combinations. The measurements highlighted the influence of liquid-layer thickness, inertia, and interfacial properties on wave amplitude, propagation, and dissipation. In order to quantitatively characterize the complex impact dynamics, machine learning-based image segmentation is employed to automatically track cavity and interface evolution from high-speed image sequences. The data-driven approach provides robust estimates of cavity geometry across a range of droplet viscosities and pool depths, enabling systematic analysis of impact-induced deformation while significantly reducing manual processing effort. Beyond liquid-liquid impact dynamics, droplet interactions with solid substrates introduce additional coupling between hydrodynamics and transported parameters, particularly under evaporative conditions. In this regard, the coupled mass and heat transport associated with the evaporation of droplets impacting heated solid substrates is investigated using dual-wavelength interferometry and high-speed IR thermography. These measurements resolve the transient vapor concentration, temperature, and heat flux fields during droplet spreading, receding, and sessile evaporation phases. The observations indicate that impact-driven transport can redistribute evaporated vapor, influencing local evaporation and heat flux through the droplet footprint, leading to deviations from classical contact-line-dominated behavior.

References:

- [1] M. Rein, Fluid Dyn. Res. 12(2), 61-93 (1993).
- [2] A.L. Yarin et al., Collision Phenomena in Liquids and Solids (2017).

[3] J. Breitenbach et al., Phys. Rev. Fluids 2(7), 074301 (2017).

Invited Talk 6

Data assimilation in flow visualization

Neetu Tiwari
IIT Hyderabad, India

Advances in flow visualization techniques such as Particle Image Velocimetry (PIV), Ultrasonic Velocity Profiling (UVP), Pressure-Sensitive Paint (PSP) and Temperature-Sensitive Paint (TSP) have significantly improved our ability to measure complex fluid flows. However, each of these techniques faces in-built limitations related to pressure field measurement, spatial and temporal resolution, measurement noise and restricted access to certain flow regions. Data assimilation provides a powerful tool to overcome these limitations by optimally combining experimental measurements with physical models and complementary sensing modalities. In this talk, I will discuss recent developments in data-assimilation-based flow visualization. First, I will discuss the estimation of pressure fields using PIV and UVP data with CFD. Data assimilation techniques also enable the reconstruction of time-resolved pressure fields even when velocity measurements are temporally limited. I will also discuss how the simultaneous estimation of pressure and temperature fields can be achieved on the same surface using PSP and TSP without mixing them through a data-assimilation method.

Invited Talk 7

Fluid thermometry using inorganic phosphor tracer particles

B. Fond
ONERA, The French Aerospace Lab, Department of Aerodynamics,
Aeroelasticity and Aeroacoustics (DAAA), Paris-Saclay University,
Meudon, 92190, France

The visualization and quantification of thermal mixing in turbulent fluid flows is key to the development of accurate turbulence modelling. These models are needed to predict the behaviour of flows in industrially relevant applications as well as geophysical flows (ocean, atmosphere, earth's mantle etc.). This talk will describe thermometry techniques based on luminescent tracer particles which can be combined with particle-based velocimetry to image both temperature and velocity in laboratory flows. The emphasis will be mostly on inorganic luminescent crystals, typically referred to as thermographic phosphors. These particles exhibit a wide range of luminescence properties, and can be chosen to match the application needs, e.g. for use in cryogenic flows, at physiological temperatures, or up to 1000 K. To measure the temperature, we can exploit either the temperature dependence of the luminescence emission spectrum or the decay time of the particles. Recent developments include high resolution measurements in submillimeter boundary layers, a proof of concept study of 3D temperature and velocity measurements in gas flows, and 2D thermometry in water with sub °C precision. Finally, we

will show how, through chemical synthesis, we can tune the particle luminescence properties to exactly match the temperature range of our application, for example around 100°C to study boiling.

References:

- [1] C. Abram et al., Appl. Phys. B 111, 155-160 (2013).
- [2] C. Abram et al., Opt. Lett. 45, 3893-3896 (2020).
- [3] M. Stelter et al., Meas. Sci. Technol. 34 074008 (2023).

Invited Talk 8

The yoga of droplets: coalescence in complex fluids

Aloke Kumar
IISc Bangalore, India

Coalescence of liquid drops is a widely observed phenomenon across a diverse range of natural and industrial processes, ranging from the formation of raindrops and the growth of tumor cells to inkjet printing. The physics involved in this seemingly simple process of coalescence is far from simple, and the rheological complexity of the fluid under investigation makes the problem even more challenging. In this talk, I will present results from our work, which has led to the discovery of the sub-Newtonian coalescence regime in complex fluids. We will discuss how these results provide a general framework for understanding the behavior of complex fluids.

Invited Talk 9

Adventures of a Droplet: A Multiscale Journey to Extreme Flow Conditions

Saptarshi Basu
IISc Bangalore, India

Droplets are silent protagonists in many natural and engineered settings – from raindrops and ocean sprays to fuel injection in turbines, microfluidic chips and even the aerosols that shaped recent pandemics. Despite the diversity of these contexts, the “autobiography” of a droplet is guided by a set of universal physical principles. This colloquium will take the audience on a journey across these domains, uncovering how droplets evaporate, deform, fragment, and interact with their surroundings under a wide spectrum of flow conditions. The adventure finally leads us to the phenomenon of aerobreakup – the disintegration of a droplet exposed to high-speed gas flows. This process unfolds as a cascade of multiscale deformations, illustrating interfacial instabilities, ligament-mediated breakup and dispersed daughter droplets. The talk will further explore how droplets respond under extreme conditions, such as shock waves, where unexpected behaviours emerge. By blending vivid experiments with fundamental models, we aim to reveal the underlying physics while highlighting its practical implications in technologies that shape our daily lives and future innovations.

Invited Talk 10

A multi-directional imaging technique for liquid jet core visualization in airblast injectors

Srikrishna Sahu
IIT Madras, India

In this talk, I will present the development and application of a multidirectional Optical Connectivity (OC) technique for the simultaneous visualization of the liquid jet core in a model cross-flow airblast injector from both side and front views. In addition to jet penetration and breakup length obtained from side-view images, the technique enables concurrent measurement of jet width and spread rate from the corresponding front-view images. Visualization of the jet core from the bottom view is also achievable. The image processing and data analysis methodologies will be discussed in detail. The airblast injector is operated over a wide range of conditions characterized by the aerodynamic Weber number and the liquid-to-air momentum flux ratio. Jet breakup characteristics are examined for several practical configurations, including cases with and without air swirl, as well as under atmospheric and elevated ambient pressures. The application of this multidirectional visualization technique provides new insights into the underlying physics of the complex jet breakup process, which will be highlighted in the presentation.

Invited Talk 11

The heat transfer in the liquid drop contact line

S. Cheverda
Kutateladze Institute of Thermophysics SB RAS, Russia

With the intensive development and improvement of technology, the need for a highly efficient and compact cooling system arises. For example, the maximum heat dissipation from a microprocessor is estimated by experts at 500 W/cm^2 , and this is expected to increase further due to the increasing number of transistors in each new microprocessor model. One developing cooling method is liquid cooling. A promising liquid cooling system uses a spray. A droplet has contact lines between three phases, called contact lines. Previous studies have shown that in the contact line region, where a high heat transfer coefficient is observed [1]. Based on this, it can be assumed that the use of a droplet system can intensify the heat transfer process. The main objective of this study was to determine the heat flux density in the contact line region of a liquid droplet on a heated surface using two independent methods. Ultrapure water was used as the liquid. Two setups were assembled: one consisted of a $25 - \mu\text{m}$ -thick foil made of a constantan alloy, connected to a DC power source [2] and the other was made of a sapphire plate placed in a frame with constant temperature. A syringe pump was used to create a liquid droplet on the heated surface, an infrared (IR) scanner, and a PC to which the scanner's observations were displayed. Since the transverse size of the microregion is very small (on the order of a few micrometers), direct measurements of the heat flux density are not yet possible. In this study, the heat flux from the foil was calculated using IR scanner images and a computational method based on solving the Cauchy problem for an elliptic equation, taking into account the

thermal conductivity of the foil material. For the sapphire plate, a direct method was used to solve the heat transfer problem based on the measured substrate temperature. The experiment in both cases showed that the highest heat flux density is observed in the contact line region, and the heat flux density in the droplet's contact line region is several times higher than the average heat flux density over the entire foil surface for water. These results are explained by the influx of heat from the foil periphery to the droplet due to the relatively high thermal conductivity of the foil material and the high evaporation rate of the liquid in the contact line region.

References:

[1] Stephan P., Brandt C., *Heat Transfer Engng.* 25(3), 78-85 (2004).

[2] Cheverda V.V. et al., *Thermophysics and Aeromechanics* 24(5), 803-806 (2017).

Invited Talk 12

Generating, observing and characterizing internal gravity waves in stratified media

Philippe ODIER
ENS Lyon, France

In this talk, I will present an overview of experimental techniques dedicated to internal gravity waves in the lab. I will show how these waves can be generated in an experimental tank, using a versatile device, allowing the production of wave beams and wave modes. Then, several techniques used to observe these waves will be described: the velocity field can be quantified using PIV, the density field using Planar Laser Induced Fluorescence (PLIF) and the density gradient field using synthetic Schlieren. Internal waves can destabilize via a non-linear mechanism called triadic resonant instability (TRI). This instability can be accurately described using these observation techniques and appropriate signal processing tools. I will also show how the combined use of PIV and PLIF allows to assess mixing properties of the waves, such as buoyancy flux, a quantity attached to vertical mixing of the ambient medium by the wave overturnings. A glance at what happens when rotation is added to the stratified medium will end this presentation.

Invited Talk 13

Coherent and intermittent flow structures in three-dimensional boundary layer transition

Sumit Tambe
IIT Madras, India

The transition to turbulence in boundary layer flows is a puzzling phenomenon, which keeps experimentalists tantalised and labs busy. The sporadic occurrence of turbulent spots in flat plate boundary layer (2D) transition continues its mystery; however, the absence of turbulent spots in three-dimensional rotating boundary layers is equally mysterious, warranting separate attention. Probing the rotating boundary layer transition on a disk/cone is a simplified approach to understanding the process of a general three-dimensional boundary layer transition. The rotation causes centrifugal, cross-flow, and viscous Coriolis instabilities on a rotating

cone, which compete for leading the boundary layer transition. Although the rotation allows theoretical simplicity, measuring/detecting the coherent flow structures on the rotating bodies is challenging due to the non-stationary flow features, moving wall, etc. This talk will show the past and recent efforts in detecting coherent flow structures on the rotating boundary layers in comparison with the measurements of the intermittent turbulent spots in the flat plate boundary layer. The results of infrared thermography and time-resolved particle image velocimetry will be discussed. The efficacy of different data processing approaches based on the POD, sPOD, wavelets, and Lagrangian Coherent Structures will be discussed.

Abstracts of Contributed Talks

Contributed Talk 1

Dual-wavelength interferometric measurements of temperature and concentration fields of a volatile droplet impacting a solid surface

Mohammad Shahdhaar
IIT Bombay, India

The evaporation dynamics of an impacting droplet have drawn significant interest due to their relevance in heat-transfer enhancement. Evaporation is driven by coupled diffusion and buoyant convection around the droplet, with diffusion governed by concentration gradients and convection by density and temperature gradients. The associated evaporative cooling near the drop-air interface further couples these transport mechanisms. Quantifying vapor concentration and temperature fields is therefore essential for understanding the overall evaporation process. We present simultaneous measurements of temperature and mole-fraction fields around an evaporating acetone droplet impacting a solid surface using dual-wavelength interferometry. Combined with high-speed imaging, this method provides spatio-temporal maps of thermal and concentration evolution during evaporation. Dual-wavelength interferometry overcomes limitations of singlewavelength approaches by using wavelength-dependent refractive-index changes to decouple thermal and compositional effects, enabling quantitative reconstruction of both fields. The influence of Weber number on impact dynamics and subsequent thermal and concentration development is examined. Concentration gradients normal to the interface are measured to determine the local evaporation rate. Results show that higher Weber numbers produce steeper gradients and thus higher evaporation rates. During early impact, the strongest gradients occur near the impact region, while by the end of spreading they become most pronounced near the three-phase contact line.

Contributed Talk 2

Taylor bubble rise through shear-thinning liquids in closed top inclined tubes

Priyanka Priyanka, Subhabrata Ray, Joydip Chaudhuri, Manish Kaushal,
Gargi Das
IIT Kharagpur, India

A Taylor bubble is an elongated, bullet-like bubble characterized by a pointed nose and a cylindrical tail, that rises through a confined medium by pushing the surrounding liquid in the downward direction. Investigating how inclination affects the motion of Taylor bubbles in tubes is important for numerous industrial systems, as it enhances our understanding of slug-flow hydrodynamics. Equally relevant is the study of draining in closed-top tubes, where a Taylor bubble grows to occupy the entire tube as it displaces the liquid (commonly referred to as infinite-tube draining bubbles). This work investigates the dynamics of such infinite tube draining Taylor bubbles in inclined tubes for both Newtonian (92% Glycerol) and shear-thinning fluid

(0.8% CMC) using videography and PIV (particle image velocimetry) measurements. Our experiments show that inclination produces a strong asymmetry in bubble shape and markedly affects the rise velocity, U_{TF} . The rise velocity increases monotonically with inclination up to a critical angle, beyond which it begins to decline. This trend is consistent with observations reported for Newtonian fluids in the literature. The PIV experiments have further quantified a 'zone of influence' immediately ahead of the bubble, which is most prominent at an inclination of 45° , the angle that also yields the maximum rise velocity. Detailed analysis indicates that such behavior arises from variations in local viscosity in the liquid film and the radius of curvature at the bubble nose. At 45° , the lower film shows the lowest effective viscosity across all tested angles and spreads over a thicker region, thereby enhancing the rise velocity and draining rate. In contrast, at 15° , both films exhibit substantially higher local viscosities, which suppress bubble rise. These findings have practical relevance for systems where gravity-driven liquid removal under inclined configurations presents operational challenges.

Contributed Talk 3

Estimation of Inertial Fog Droplet Capture on Cylindrical Fibers using Digital Inline Holography

Sohom Goswami, Nikhil Krishna Suda, Pranav Joshi, K Muralidhar
IIT Kanpur, India

The growing water crisis from population, pollution, and climate change drives research interest in alternative sources of water. Fog harvesting involves capturing airborne micro water droplets on porous structures, offering a promising supplemental freshwater solution. The probability of a fog droplet being captured by a fiber (called capture efficiency in fog harvesting literature), usually circular cylindrical in shape, is largely governed by the fluid mechanics of droplet-laden flow past a cylinder. While several theoretical models have been proposed, experimental studies are scarce in existing literature. The capture efficiency, governed by Stokes number (St), scales as square of fog droplet diameter, making it imperative to measure the fog droplet size distribution. In this work a digital inline holography (DIH) based method is developed for estimating fog droplet size distribution. Using DIH the droplet images are reconstructed at their appropriate locations in 3-dimensional space using minimum intensity and maximum sharpness criteria, and their size is obtained at their plane of best focus using subpixel edge detection algorithm. The droplet size distribution obtained is then used to find capture efficiency. Further, wind tunnel studies on inertial fog droplet capture on single fibers will be performed. Parametric studies using LED based PIV will be performed to study the flow field around fog collecting fibers and delineate the effect of fiber shape, diameter and transient droplet growth on capture efficiency. The results of these studies will guide design of superior fibers with tuned geometries to enhance droplet capture performance.

Contributed Talk 4

Experimental Study of Falling Films over Horizontal Tubes Using Digital Holographic Interferometry

Jawahar Prakash
IIT Madras, India

The study of falling films over horizontal tubes is of significant importance in the design and optimization of falling-film heat exchangers, which are widely employed in desalination, refrigeration, and various process industries. Although extensive literature exists on falling-film hydrodynamics, most studies primarily address film thickness, with far fewer focusing on the coupled heat and mass transfer mechanisms. Moreover, the limited works that do investigate heat and mass transfer are predominantly numerical, highlighting the need for high-resolution experimental measurements. Digital Holographic Interferometry (DHI), a proven non-intrusive optical technique, has demonstrated strong capabilities in resolving evaporation-driven refractive index variations at liquid-vapour interfaces. In this work, DHI is employed to simultaneously measure both the film thickness and the evaporation characteristics of an acetone falling film flowing over a horizontal tube. The off-axis holographic configuration enables extraction of spatial intensity and phase information from recorded interferograms. Variations in the reconstructed intensity field are used to estimate local film thickness, while phase changes provide the refractive index variations in the vapour region surrounding the film. These refractive index changes are further mapped to acetone vapour concentration, enabling quantitative characterization of the vapour field. By analysing the temporal evolution of acetone vapour concentration, the instantaneous evaporation rate is determined. The results of this study demonstrate the potential of DHI as a comprehensive diagnostic tool for resolving coupled hydrodynamic and mass-transfer processes in falling-film systems, offering valuable experimental insight to complement existing numerical studies.

Contributed Talk 5

Data-Driven Prediction of Fuel Spray Dynamics using a Novel Hybrid Machine Learning Technique

Sathishkumar Balasubramani, Kalil Basha Jeelan Basha, Srivishnu
Janakiraman, Shivangi Das, Vedharaj Sivasankaralingam
NIT Tiruchirapalli, India

Precise control of the fuel spray dynamics is crucial for enhancing combustion stability and reducing emissions in modern Direct Injection (DI) engines. However, a detailed study on spray dynamics under realistic operating conditions remains experimentally demanding and expensive. Hence, many researchers have employed machine learning techniques to predict the spray dynamics in recent times. Therefore, in the current study, the spray dynamics of iso-octane were investigated under various operating conditions, and its spray characteristics were predicted using a novel hybrid machine learning technique. The visualization of iso-octane sprays was carried out in an optically accessible spray chamber using the shadowgraph imaging technique. Herein, a Phantom high-speed camera was utilized to record the spray evolution and the

captured images were processed in MATLAB to extract spray characteristics. Further, a novel hybrid machine learning technique was developed to accurately predict the experimental spray dynamics. The spray development process for iso-octane at fuel injection pressures of 50 and 100 bar, under ambient conditions of 10 bar and 373K. The experimental results showed that the fuel injection pressure and ambient pressure have a greater influence on the development of the iso-octane spray compared to the ambient temperature. In addition, no significant variation in spray penetration lengths was observed after 1 ms ASOI (after start of injection) for fuel injection pressures of 50 and 100 bar. The occurrence may be attributed to the high chamber pressure of 20 bar, which resists penetration at the downstream of the spray. The proposed machine learning model achieved an accurate prediction of spray dynamics, with a high coefficient of determination ($R^2 > 0.95$) and low error values. Thus, the model is reliable and shall reduce the dependence on expensive optical diagnostics and computationally expensive CFD simulations.

Contributed Talk 6

Mixed-Convection Free-Shear Flow Through Porous Screens

Shashikant Pawar
Plaksha University, India

Classical work on flow through screens has mainly dealt with pressure-driven or ducted flows, where screens are treated as resistance elements or as devices for modifying turbulence [1, 2]. These studies established pressure-drop correlations and examined flow-conditioning behavior. Little attention has been given to free-shear flows interacting with screens, especially when buoyancy and forced convection act simultaneously. The present study explores this less examined regime. A vertical jet of heated air ($150 - 200^\circ\text{C}$) is issued into quiescent surroundings and made to pass through steel wire meshes. The meshes used were of four different mesh counts. The objective is to understand how porosity influences the evolution of the mixing and the resulting heat transfer. Shadowgraph imaging at 200 fps is used to visualize the flow. Hot-wire anemometry and T-type thermocouples provided the pointwise measurements of velocity and temperature. Velocities are also estimated from the sequential shadowgraphs. Shadowgraphs (a) with, and (b) without a screen are shown in figure-1. Initial observations show that the screen produces a marked change in the velocity and temperature distribution. Finer meshes weaken and diffuse the jet core immediately downstream, with stronger lateral spreading and earlier mixing. Coarser meshes allow a more intact core but introduce periodic distortions associated with the wake of the mesh elements. These changes are reflected in the thermal field, depending on the mesh number. These observations are complementary to the earlier findings on influence of near-wall perturbations in buoyancy-driven convection on local flow dynamics and heat transport [3]. Overall, the results indicate that screen porosity is a useful passive parameter for tuning the balance between forced and buoyant components in mixed convection. Further experiments with varied spacing and multiple mesh layers are planned to map the transitions in shear-layer structure and the corresponding heat-transfer response.

Contributed Talk 7

Pore-Scale Visualization of Multiphase Flow in Enhanced Oil Recovery Using a PDMS Microchannel

Nagur Shaik
IIPE, India

Understanding pore-scale flow mechanisms is essential for optimizing Enhanced Oil Recovery (EOR) processes. In this study, a microchannel-based visualization system was developed to experimentally investigate multiphase displacement behavior in porous media analogues. The micro model was prepared using Polydimethylsiloxane (PDMS) – a silicone-based organic polymer widely used in microfluidic device fabrication. The fabricated model replicated the complex geometry of sandstone formations. A highspeed camera integrated with optical microscope was employed to capture dynamic displacements during water flooding, polymer flooding, surfactant flooding and nanoparticle flooding under controlled flow conditions. The experiments demonstrated critical pore scale mechanisms such as snap off, viscous fingering and capillary trapping, which significantly influence residual oil formation and oil recovery efficiency. Image analysis of the flow sequence allows quantification of saturation changes and visualization of interface dynamics. The investigation finds that optimized flooding conditions and chemical formulations can effectively reduce snap-off and improve microscopic recovery. The micromodel provides a transparent, cost effective and repeatable platform for visualizing multiphase interaction under reservoir conditions. The novel integration of high-speed visualization and quantitative image analysis bridges the gap between laboratory-scale and field-scale EOR performance prediction. The findings indicate that microfluidic visualization is a powerful diagnostic tool for understanding pore-scale flow mechanisms, offering valuable insights for the design of advanced and efficient EOR strategies.

Contributed Talk 8

Direct Adhesion Force Characterization on Superhydrophobic and Patterned Surfaces Using Cantilever Deflection

Abhilash M. S., Kiran Raj M
IIT Madras, India

Understanding droplet adhesion on engineered surfaces is important for applications such as self-cleaning coatings, anti-icing, and microfluidic devices. Contact angle measurements are commonly used to evaluate wettability, but they only describe the droplet shape and do not directly measure adhesion forces, especially on superhydrophobic surfaces. Moreover, optical limitations near the three-phase contact line can introduce errors when adhesion is estimated indirectly from contact-angle measurements. In this study, we present a visualization-based approach for directly measuring droplet adhesion forces using cantilever deflection. An optical fiber cantilever (stiffness $\approx 18,900\mu N/m$) was employed as a force transducer, with a micro-droplet attached at its tip. The interaction between the droplet and vertically mounted substrates was recorded using high-resolution imaging at 100 fps. Adhesion force was calcu-

lated from the measured cantilever deflection using Hooke's law. This method enables real-time visualization of force evolution during approach, holding, retraction, and detachment. Two substrates were investigated: (i) a fully coated superhydrophobic (SHP) surface and (ii) a patterned SHP/hydrophilic surface. The fully SHP surface exhibited a static contact angle of 136.32° with low contact angle hysteresis (5.25°), indicating high water repellency. In contrast, the patterned surface showed a slightly higher contact angle (140.26°) but increased hysteresis (11.29°), suggesting enhanced contact-line pinning. Cantilever deflection measurements revealed that adhesion on the fully SHP surface was independent of pull-back velocity over the tested range, confirming coating stability and robustness. However, the patterned surface exhibited distinct velocity-dependent behavior. At low retraction velocities, partial depinning events were observed prior to full detachment. As velocity increased, the maximum cantilever deflection decreased, indicating reduced measured adhesion. The adhesion force at an intermediate velocity of 0.23mm/s showed strong agreement with analytical estimates based on contact angle measurements, validating the approach. Deviations at very low and high velocities were attributed to motor stepping effects and inertial influences, respectively, highlighting the existence of an optimal velocity window for accurate force measurement.

Contributed Talk 9

Flow-field and Acoustic Characterization of an Actively Controlled Mach 0.5 Jet

Ambica Singh, Srinivasa Rao Lavala, Arun Kumar Perumal, Arnab Samanta

Indian Institute of Technology Kanpur, India

In recent years, jet-noise reduction via fluidic injection has gained significant attention in the literature, wherein multiple secondary jets located at the nozzle exit are employed to manipulate the primary jet. In the present work, we document the effect of a downstream-positioned fluidic injector on the noise characteristics of a Mach 0.5 jet. The study investigates two fluidic injectors ($N = 2$, where N denotes the number of injectors), arranged symmetrically about the jet axis. These injectors are located downstream of the potential core at $x/D = 2$ (D represents nozzle exit diameter). Experimental investigations were conducted on a high subsonic, single-stream Mach 0.5 jet, corresponding to the nozzle diameter-based Reynolds number of $Re = 2.2 \times 10^5$.

Contributed Talk 10

Evaluation of agglomerate particle size distribution in aluminized RDX based AP/HTPB composite propellant flames through image analysis

Dhanraj Chimurkar, Jayesh Upadhyay, Krish Raibole, Kanagaraj Gnanaprakash, Rohit Sherawat, Guddu Kumar, Mukesh Jain
High Energy Materials Research Laboratory, DRDO, Pune, India; Indian Institute of Technology Hyderabad, India

The agglomeration of metal particles during the combustion of aluminised composite propellants results in a substantial loss in the rocket motor's overall performance. Quantifying this loss and to minimise its effects, requires analysing the intricate phenomenon of agglomeration on and near to the propellant's burning surface. Additionally, the propellant's burn rate is also a primary facet that governs its performance while also providing a thermodynamical insight into the combustion. Thus, evaluating the alumina agglomerate particle size distribution along with the burn rate with ease, over a wide range of pressures is essential. The present study has been focused on employing a non-intrusive methodology that makes use of high-speed imaging and image analysis techniques to evaluate the agglomerate particle size distribution and the burn rate in the pressure range of 0.1 MPa to 4.0 MPa. One AP/HTPB and 4 AP/HTPB/RDX based propellants with aluminium content ranging from 1% to 20% have been analysed in this study. The effect of addition of nitramines on the agglomeration has also been showcased by estimating the particle size distribution through image analysis. Moreover, the variation of the burn rate along the propellant's height over time has also been investigated and compared with the theoretical assumption of normal burning. The calculated burn rate values showed a $\pm 5\%$ deviation from the standard values.

Contributed Talk 11

Stabilizing Microfluidic Droplet Imaging Using a CD-Drive-Based Microstepping Linear Actuator

Antony Xavier, Mythrayi Malli Ramshankar, Kiran Raj M
Indian Institute of Technology Madras, India; SVNIT Surat, India

Droplet-based microfluidic systems enable high-throughput generation and precise control of sub-microlitre droplets carrying tailored chemical or biological payloads within an immiscible carrier fluid, with applications in single-cell analysis, nanomaterials synthesis, directed evolution, and 3D cell culture [1]. Real-time imaging of these droplets is essential for monitoring and control; however, their rapid motion requires high-speed cameras or stroboscopic techniques for time-resolved visualization [2]. Moreover, such approaches are typically limited to time-resolved imaging within the camera field of view.

To achieve time-resolved droplet imaging using standard DSLR camera over larger length scales, a mechanism is created by repurposing a CD drive's linear actuator. The mechanism comprises of a CD drive's linear actuator driven by a microcontroller that can retain the moving

droplets in microfluidic channel within the field of view. It enables the time resolved imaging of microliter droplets moving with speeds ranging from 1 mm/s to 1 cm/s over a length of 2 cm which is 10 times higher than the dimension of the field of view. The videos obtained likewise can be used to study internal flow in slugs using μ -PIV and can serve as an experimental benchmark for simulations. Further, due to the modular design of the setup, it can complement other imaging techniques to obtain novel information.

Contributed Talk 12

Dynamics of Elongated Taylor Bubbles in non-Newtonian Fluids

Manikandan Padmanaban, Arul Prakash K
Indian Institute of Technology Madras, India

Microchannels with two-phase elongated Taylor bubble flow pattern are widely used in applications such as microfluidic devices, chemical reactors, and heat exchangers. Over the past two decades, Taylor bubble dynamics in Newtonian fluids have been extensively investigated through experimental, numerical and analytical approaches, owing to their strong potential for enhancing heat transfer and mixing performance. In contrast, studies involving Taylor bubble in non-Newtonian fluids remain relatively limited, despite their significance in practical systems where biological fluids, emulsions, and polymeric solutions often exhibit inelastic shear-thinning behavior [1]. In this work, the influence of shear-thinning rheology on Taylor bubble dynamics is examined through two-dimensional axisymmetric numerical simulations within the open-source finite volume framework OpenFOAM [2], with the continuous phase modeled using the Carreau fluid formulation. A systematic parametric analysis is performed across a range of shear-thinning indices to quantify how the rheological behavior controls the bubble shape and the recirculation patterns inside the bubble. The results demonstrate that non-Newtonian rheology substantially modifies the elongated Taylor bubble shape. As the shear-thinning effect becomes weaker, the effective viscosity of the continuous phase decreases relative to the Newtonian zero-shear-rate viscosity, leading to reduced viscous stresses around the bubble. This reduction in viscosity suppresses bubble elongation and promotes axial contraction, revealing a strong coupling between rheology, effective viscosity variation and bubble shape evolution. Furthermore, variations in shear-thinning behavior significantly alter the size of internal recirculation within the liquid slug, which in turn affects the associated mixing characteristics. Overall, these findings provide fundamental insight into Taylor bubble behavior in non-Newtonian fluids and offer valuable guidelines for the design of microchannel systems where controlled bubble transport is essential.

Contributed Talk 13

Coherent Structures in a Turbulent Jet

Vivek Mugundhan, Tiernan Casey, Jun Sakakibara, Sigurdur Thoroddsen
King Abdullah University of Science and Technology, Saudi Arabia;
Meiji University, Japan

Volumetric velocity-measurement techniques such as Tomographic Particle Image Velocimetry (Tomo-PIV) have enabled researchers to study turbulent flows by visualization of coherent structures (CS). Herein, we employ conditional averaging of the 3-D velocity field to visualize and characterize CSs in the far field of a fully developed round turbulent jet, for $Re_D = 2640$, 5280 and 10700, based on the nozzle diameter D . The time-resolved 3-D velocity field is measured using the Scanning Tomo-PIV technique introduced by Casey et al. [1] with four high-speed cameras. A galvanometer sweeps the laser-volume slice to obtain a thicker measurement region, compared to the conventional Tomo-PIV technique. Conditional velocity field obtained by imposing conditions on azimuthal vorticity at different reference locations, over 10-15 independent experimental runs, revealed the existence of horseshoe structures. These structures corroborate well with the instantaneous C-shaped loops that can be seen frequently in time series. The $m=1$ wave number Fourier-based proper orthogonal modes of vorticity capture these C-shaped structures [2]. In the inner region ($r \sim D$), the upright horseshoes appear with their head closer to the axis and legs pointing downwards. In the outer region ($r > 4D$), their legs point upwards towards the axis with head farther away from the axis (inverted). The structures are inclined at $40-60^\circ$ to the mean flow, and the distance between their legs lies in the range $0.2r_{0.5}-0.4r_{0.5}$, where $r_{0.5}$ is the jet half-radius. The volumetric measurement using high magnification also enables us to obtain better estimates of kinetic-energy dissipation rate using all velocity gradient terms and thus Kolmogorov scale.

Contributed Talk 14

Reconfigurable Microfluidics Using Multiple Magnetic Microrobots

Dineshkumar Loganathan, Dong-Ming He, Kai-Wei Chen, Chia-Yuan Chen
National Cheng Kung University, Taiwan

Magnetically actuated microrobots have emerged as versatile microfluidic flow modulators capable of performing on-demand fluidic operations without requiring integrated valves or structural modifications. However, the mechanisms governing microrobot-induced flow formation, shear generation, and hydrodynamic coupling have remained insufficiently characterized, particularly when multiple agents were employed for coordinated microfluidic functions. To address this gap, the proposed work was focused on quantifying the flow fields generated by independently controlled magnetic microrobots and on establishing the fundamental flow physics that enabled reconfigurable microfluidic behavior. Micro-particle image velocimetry (μ -PIV) was employed to investigate the shear-rate distributions and vortex structures formed around the microrobots. The results revealed the formation of distinct flow patterns, including dipolar

shear fields surrounding individual agents and directionally biased flow arising from constructive or destructive interference when two microrobots were actuated with different rotational inputs. Based on these visualization-derived physical insights, microrobot configurations and actuation schemes were subsequently selected to demonstrate the particle manipulation task. Particle transport along uniaxial and curvilinear trajectories was achieved by positioning microrobots within regions of strong shear gradients, allowing the induced flow to steer particles predictably toward predefined downstream targets. Thus, the integration of μ -PIV-based flow analysis with independently controlled magnetic microrobots established a framework through which reconfigurable microfluidics was achieved and governed by the underlying shear-driven flow mechanisms.

Contributed Talk 15

Shock-Dominated Flow Features in Supersonic Rectangular Impinging Jets

Revathy RK

Indian Institute of Technology Kanpur, India

Impinging jets are essential to aerospace propulsion and VTOL/STOVL aircraft operations because of their high efficiency in heat, mass, and momentum. When high-speed jets interact with nearby surfaces, they generate intense unsteady loading and elevated noise levels, including discrete impingement tones [1]. Unlike free jets, impinging jets exhibit complex flow-acoustic feedback involving shear-layer instabilities, surface pressure fluctuations, and upstream-propagating acoustic waves [2]. Previous studies have reported strong tonal noise, mode switching, and sensitivity to jet Mach number, nozzle-to-plate distance, and plate orientation, particularly in supersonic rectangular jets. For this study, the experiments were conducted in an open-jet facility at IIT Kanpur, using a rectangular converging nozzle (AR-3). The impinging jet was kept at two times the jet diameter ($2D$). The jet-plate interaction was visualized using a Z-type schlieren system with high-speed imaging to capture the unsteady shock-shear layer dynamics during impingement. The full-length paper will discuss the detailed analysis of this study.

Contributed Talk 16

Liquid-in-liquid encapsulation during immiscible drop-pool impact

Keshav V

Indian Institute of Technology Madras, India

Drop-pool impact is an extensively studied phenomenon as it finds application in many natural and industrial processes. Since the pioneering work of Worthington over a century ago, significant advances have been achieved in this field with the advent of sophisticated visualization techniques. Most of these studies are limited to drop and pool liquids being same or miscible to each other. Addition of immiscibility to the equation can substantially alter the dynamics of crater and jet, two of the important characteristic features of any drop-pool impact problem.

Different physical phenomena can be observed depending on the relative properties of the interacting liquids. In the present study, a case of liquid-in-liquid encapsulation during immiscible drop-pool impact has been investigated. Encapsulation phenomenon has a wide range of practical relevance in applications like pharmaceuticals, food processing, agriculture, oil and gas industry and inkjet printing. While the majority of existing studies focus on microencapsulation, the present work investigates encapsulation phenomena at the millimetric length scale. Here, a liquid drop which is denser, more viscous, and possesses a higher surface tension is made to impact an immiscible deep pool. High-speed imaging shows sequential capillary induced singularities at the drop-pool-air interfaces resulting in distinct encapsulation configurations. This study aims to explain how the dynamic interplay among interfacial tension, viscous and inertial forces, governs the resulting encapsulation configuration.

Contributed Talk 17

Spiky contacts during the impact of an emulsion drop on a solid surface

Krishna Raja Dharmarajan

King Abdullah University of Science and Technology, Saudi Arabia

Ultra-high-speed interferometry was used to elucidate the contact dynamics of oil-in-water emulsion drops impacting on molecularly smooth solid surfaces [1]. In contrast to monodisperse liquid drops, emulsion systems demonstrate heterogeneous phase dynamics in response to the severe deceleration field ($10^5 m/s^2$) generated by the compressed air layer beneath the drop surface. When the dispersed oil phase exceeds the density of the aqueous phase, the resulting differential inertial response triggers the nucleation of thin spikes that extrude out of the free surface. These spikes form when the impact Weber number exceeds a critical value of $\simeq 10$. Time-resolved interferometric imaging, at frame-rates up to 7 million fps, shows the emergence and shape of these spikes leading to the local contacts with the solid. We characterize the tip curvature and capillary pressure affecting their dynamics as they emerge and can touch the substrate before the main outer ring of contact. These findings demonstrate that density-induced differential phase response alters the mechanism governing impact morphology and contact line behaviour.

Contributed Talk 18

Visualizing Viscous Dissipation in Vertical Planetary Mixer

Kuralamuthan Veerapandiyan, Jayachandran T, Arul Prakash K

Indian Institute of Technology Madras, India

Planetary mixers are widely used in propellant, food, and pharmaceutical processing, where highly viscous slurries experience strong shear-induced heating that can affect product quality and safety. Building on earlier work that characterized mixing dynamics and power consumption in planetary configurations, this study uses CFD-based viscous-dissipation imaging to relate local shear fields to global power draw and thermal loading in a three-agitator vertical plan-

etary mixer. The configuration comprises one central agitator rotating about the vessel axis and two outer agitators executing combined gyration and self-rotation, producing complex, time-dependent shear layers in the working fluid. A modified OpenFOAM-v2406 pimpleFOAM solver is employed to solve the three-dimensional, unsteady, incompressible Navier–Stokes equations and energy equation with an explicit viscous-dissipation source term for a highly viscous fluid (viscosity 1000 Pa·s, density 1770 kg/m³). Spatial discretization uses Gauss-linear schemes, with a Gauss linear-upwind scheme for temperature convection and no-slip, zero-gradient pressure and adiabatic wall boundary conditions. OpenFOAM function objects compute viscous dissipation and shear rate fields, which are post-processed to obtain spatial temperature distributions, viscous dissipation maps, and volume-integrated power. Contours reveal that dissipation is strongly localized in thin layers around the blades and in narrow gaps to the vessel wall, while the bulk remains weakly dissipative. Additionally, planetary motion transports heat from central high-shear zones toward outer regions. The study demonstrates how viscous-dissipation imaging can directly connect local flow physics, global power consumption, and temperature rise, providing a quantitative framework for optimizing blade geometry and operating conditions in industrial planetary-mixing processes.

Contributed Talk 19

Development of Tomographic Background-Oriented Schlieren for 3D density measurement in buoyant plumes

Javed Mohd., Debopam Das
Indian Institute of Technology Kanpur, India

Three-dimensional (3D) measurements are often complex, and only a limited number of techniques are available in the area of fluid dynamics. Consequently, new and 3D measurement techniques have been continuously evolving in recent times. A variant of the Tomographic Background-Oriented Schlieren (TBOS) method has been developed, which is an extension of the classical three-step method and is applied to 3D density field measurement in buoyant plumes. Three-dimensional density field measurements of buoyant plumes, particularly the lazy plumes, are carried out using an in-house-developed experimental rig and associated MATLAB-based processing codes [1]. The experimental rig consists of eight cameras facing random-dot backgrounds placed diametrically opposite, mounted circumferentially around the buoyant plume. Ray deflection (dot displacement) is calculated using a cross-correlation method. A finite-difference-based Poisson solver is employed to compute the projected integrated density. Reconstruction is performed using the Simultaneous Algebraic Reconstruction Technique (SART). The resulting 3D density field data is validated using similarity solutions and simulated data from the literature. We demonstrate that the 3D density field serves as valuable data for studying buoyant plume dynamics. For instance, in the case of lazy plumes, the measured density field clearly captures the puffing phenomenon, characterised by the alternate shedding of a low-density pocket pinching off from the source.

Contributed Talk 20

Drop shape and velocity field in drop splash

Raghavendra S

Indian Institute of Technology Kanpur, India

The dynamics of a liquid drop impact on a liquid surface is studied experimentally on deep water by using high speed imaging and particle image velocimetry techniques. This study has provided deeper understanding of the effect of drop shapes on the fully developed splashing. Based on the experimental observations, it can be concluded that the liquid drops after impact with the target liquid, the kinetic energy possessed by the impinging drop divides between the drop and the target. Prolate drop, after the impact on the free surface of water, distributes kinetic energy more in the vertical direction than in the horizontal direction. Oblate drop, after the impact on the free water surface, distributes kinetic energy more in the horizontal direction than in the vertical direction, and spherical drop distributes it almost symmetrically. This uneven distribution of transferred kinetic energy from the drop to the target liquid is possibly the reason for variations in the various features observed in crown, cavity, and jets for different drop shapes at the time of impact. Such as crown shape, cavity shape and size, and maximum jet height. Prolate drop at the time of impact gives rise to unevenly expanded unsymmetrical thick crown, oblate drop at the time of impact gives rise to unevenly expanded unsymmetrical thin crown and spherical drop at the time of impact gives rise to symmetrically expanded crown. Prolate drop at the time of impact gives rise to longer jets than the jets formed due to oblate and spherical drop at the time of impact. Oblate drop at the time of impact gives rise to the smallest jets. It is also found that the velocity field around the cavity is majorly influenced by the drop shapes at the time of impact.

Contributed Talk 21

Investigation of Dense Particulate Suspensions in Stirred Tanks by Real-Time X-ray Radiography Technique

Asif Bhat, T Saravannan, S Bagavathiappan, S Mahadevan, D Sujish,
Shiv Prakash Ruhela, T. V. Prabhu

Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu,
India

This study aims to understand the underlying behaviour of dense spherical drops resulting from dispersions formed during high-temperature liquid–liquid extraction used in the actinide drawdown process of pyroprocessing. Here, the suspension of dense particles in an aqueous medium in a stirred tank was considered for investigating the dynamic characteristics. Stainless steel balls of diameter 0.9–1.6 mm were used in demineralised (DM) water to create a suspension. Experiments were conducted at room temperature in a transparent, baffled cylindrical stirred tank with a diameter of 70 mm and a liquid height (H) of 70 mm. The agitator consists of a three-bladed, pitched turbine (down-pumping mode) impeller with a 30 mm diameter, operating at impeller speeds of 150–3000 rpm. The influence of impeller speeds on the suspension of steel balls was studied using in-situ radiography. The X-ray images were

acquired continuously under identical exposure, geometrical magnification, and recorded at 25 fps (normal mode), 50 fps (2×2 -pixel binning), and 100 fps (4×4 -pixel binning) as video files.

It was observed that, upon agitation, the balls become just suspended at impeller speed (N) of 1635 rpm, which is defined as the critical speed (N_c) for the system. As the speed increases, the balls rise further and become suspended in the upper regions of the liquid column in the tank. The lift height attained or the axial distribution (h) of the balls was captured with radiography. Using ImageJ, the frames were analysed, and displacements of the balls and axial distribution were assessed. The variation in axial distribution of the steel balls with impeller speed or the Reynolds number is evaluated.

Contributed Talk 22

Chaos in Stokes Flows enhances stirring

Prabhash Kumar
IIT Madras

We investigate how chaos and efficient stirring can arise in slow, viscous (Stokes) flows through controlled temporal asymmetry. Using experiments and simulations of pulsatile flow in a bifurcating T-junction, we introduce subperiodic variability via a phase angle between oscillatory boundary motions. We show that the interplay between phase angle and oscillation frequency drives a transition from time-periodic to chaotic fluid trajectories, even at vanishing Reynolds numbers. Chaos emerges through periodic switching between open and closed streamlines, enabling stretch-and-fold dynamics. A regime map in parameter space identifies conditions for chaotic stirring, with implications for transport in physiological, microfluidic, and industrial viscous flows.

Contributed Talk 23

Comparative Experimental Investigation of Spray Characteristics of Boron-Loaded Slurry and Gel Fuels

Prabhudeva P
Alliance University

Liquid hydrocarbon fuels have been extensively employed in air-breathing propulsion systems for several decades. In recent years, the incorporation of energetic metal particles, particularly boron, into hydrocarbon fuels has gained significant attention as an effective approach to enhance fuel energy density [1]. Boron is especially attractive due to its high gravimetric and volumetric heat of combustion. Despite these advantages, maintaining a stable dispersion of boron particles within liquid fuels remains a critical challenge [2]. To address this, various stabilizing agents are employed, resulting in two broad classes of metallized fuels: slurry fuels and gel fuels. While gel-based stabilizers significantly improve particle suspension and storage stability, they also markedly increase fuel viscosity, thereby adversely affecting flowability and atomization performance [3]. Slurry fuels, on the other hand, exhibit comparatively lower viscosity and improved atomization characteristics, though particle sedimentation remains a

concern [4]. Although several studies have investigated the rheological or spray behaviour of boron-loaded slurry and gel fuels individually, a systematic, direct comparison of their atomization characteristics remains lacking. In the present work, an extensive experimental investigation is carried out to comparatively evaluate the rheological behaviour and spray characteristics of boron-loaded slurry and gel fuels under identical operating conditions. Key spray parameters relevant to atomization quality are analyzed in conjunction with rheological measurements to establish correlations between fuel structure and spray performance.

Selected Poster Presentations

Table 1: Poster Presentation Details

S.No	Paper ID	Paper Title	Poster Presenter	Authors (Affiliation)*
1	15	Droplet dynamics of Newtonian and Non-Newtonian fluids on inclined superhydrophobic surfaces	Balantrapu Venkata Rama Sai Krishna	VIT-AP
2	21	Electrothermal flow of non-Newtonian fluid through wavy channel	Bijoy Dutta	Banaras Hindu University
3	74	On the Investigation of Near Wake Structures of Heaving and Pitching Elliptical Cross-sectional Wing in Quiescent Fluid	Gangadhar Venkata Ramana Pinapatruni	IIT Kharagpur
4	112	Influence of elliptical bodies on electrothermo-hydrodynamics (ETHD) traits and ML prediction of heat transfer	Rajeswari Chokkapu	GMR Institute of Technology
5	120	Numerical Study of Fluidic Thrust Vectoring Accompanied by a Guide Plate and Counterflow Configuration	Bhimu Daddimani	NIT Karnataka
6	37	DROP IMPACT STUDIES ON BANANA LEAVES	Krishnadas Nampothiri	Amrita Vishwa Vidyapeetham
7	49	Unsteady Electroosmotic Transport of Viscoelastic Fluids Under Pulsed Electric Fields	Bhanu Singh	Banaras Hindu University
8	57	Flow Visualization of Fluidically-Vectoring Jets	Saiphaneendra Karuchola	IIT Kanpur
9	60	Numerical Simulation of Bingham fluid flowing over a superhydrophobic wall modelled by liquid-air interface slippage	Geetanjali Chatopadhyay	MNIT Jaipur
10	103	Optimization of 3D Printed Microfluidic Devices for Organ-on-Chip Applications	Devashree Sakharkar	IIT Madras
11	126	Optimizing formation of spheroids inside droplets for microfluidics-based high throughput screening	Sachin Thomas	IIT Madras
12	135	Visualizing spermatozoa on a tricky trail: A mimic of the female reproductive system	Faaiza Ibrahim	IIT Madras
13	142	Background Oriented Schlieren imaging applied to post impact droplet evaporation	Partha Dutta	IIT Madras