
The 1st Symposium on
Theoretical and Applied Mechanics
6th – 7th November 2025
Khalifa University, Main Campus, Abu Dhabi, UAE

TABLE OF CONTENTS

1 About Symposium on Theoretical and Applied Mechanics

The 1st Symposium on Theoretical and Applied Mechanics (STAM1) evolved from the successful 1st (2023) and 2nd (2024) UAE Thermo-Fluids Days. This symposium broadens its focus to encompass both foundational and emerging topics in general mechanics, solid mechanics, fluid mechanics, biomechanics, and other related fields, such as data-driven and machine learning modeling applied in mechanics. STAM1 is a forum designed to bring together researchers, scholars, engineers, and practitioners working across all areas of mechanics to discuss the latest research advances in the broad areas of theoretical and applied mechanics. In addition, STAM1 allows researchers from institutions in UAE and beyond to meet, share ideas, and establish collaborative research to advance academic institutions. STAM1 will encompass the five following intersecting fields:

- Fluid Mechanics & Thermo-sciences
- Solid Mechanics & Materials
- Biomechanics & Bioengineering
- Computational & Data-Driven Mechanics
- Dynamics, Control & Extreme Environments

2 Sponsors

The sponsors of 1st Symposium on Theoretical and Applied Mechanics are gratefully acknowledged.

Khalifa University (https://www.ku.ac.ae/)

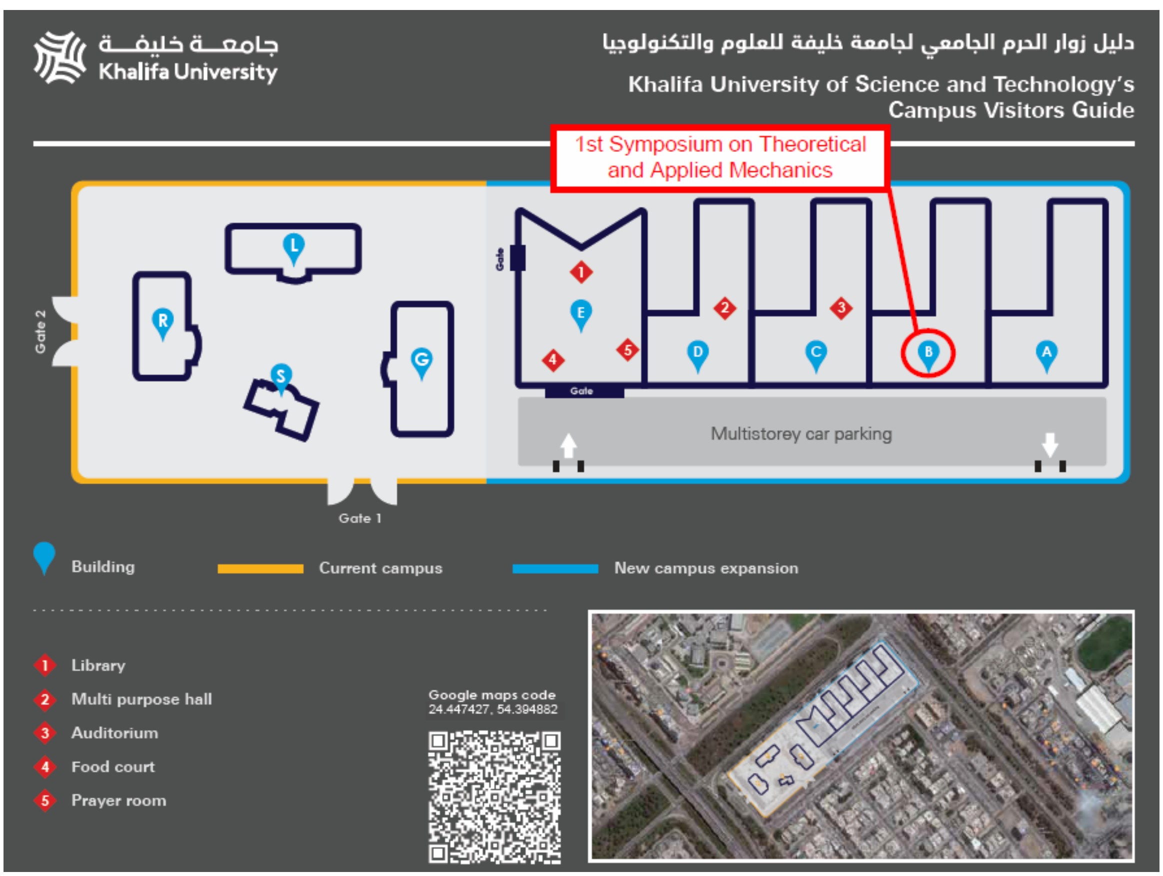
Mechanical and Nuclear Engineering Department, Khalifa University. (https://www.ku.ac.ae/academics/college-of-engineering/department/department-of-mechanical-and-nuclear-engineering#news)

Business Communications LLC (https://www.bcluae.com/)

Cadence Design Systems (https://www.cadence.com/en_US/home.html)

3 Venue Maps


جامعة خليفة
Khalifa University
Location map
1st Symposium on Theoretical and Applied Mechanics
Abu Dhabi Police HQ
Multi story car parking
A
B
C
D
E
G
L
R
S
Abu Dhabi Corniche


جامعة خليفة
Khalifa University
دليل زوار الحرم الجامعي لجامعة خليفة للعلوم والتكنولوجيا
Khalifa University of Science and Technology's Campus Visitors Guide
1st Symposium on Theoretical and Applied Mechanics
Gate 2
Gate 1
Gate
Multistorey car parking
Building
Current campus
New campus expansion
1 Library
2 Multi purpose hall
3 Auditorium
4 Food court
5 Prayer room
Google maps code
24.447427, 54.394882

جامعــة خليفــة
Khalifa University

دليل زوار الحرم الجامعي لجامعة خليفة للعلوم والتكنولوجيا

Khalifa University of Science and Technology's Campus Visitors Guide

اللباس الواجب ارتداؤه

يتوجب على الزوار، بغض النظر عن دينهم أو جنسيتهم ارتداء ملابس لائقة ومناسبة للجو العام للحرم الجامعي. من الضروري أن يحترم كل زائر معايير المجتمع الإماراتي وأن يبتعد عن كل ما قد يسيء إلى الثقافة والعادات والتقاليد المحلية أو ما ينافي الذوق العام.

يجب ملاحظة النقاط التالية فيما يتعلق بالملابس الواجب ارتداؤها أثناء زيارة الحرم الجامعي، مع العلم أنه يجب ارتداء ملابس واقية خاصة للمختبرات عند الضرورة.

Dress Code

Visitors, irrespective of religion or nationality should dress in a modest and appropriate manner on campus. It is required that every visitor respects the norms of UAE society and he/she should not dress in a way that may offend cultural sensitivities and/or may not be within acceptable general taste.

The following points must be observed regarding visitors dress at the University campus. It is noted, however, that special protective clothing for laboratories shall be worn as necessary.

تعليمات ملابس الزوار من الذكور

- يجب على الزوار الذكور ارتداء القميص والبنطلونات الطويلة / الجينز. كما يجب تجنب ارتداء البنطلونات القصيرة (الشورت) أو القمصان بلا أكمام.
- يجب تجنب الملابس التي تعرض كتابات أو رسومات أو صور مسيئة أو مخلة أو تعتبر غير مقبولة.
- يجب تجنب إبراز الوشوم والحلق.

Male Visitors Dress Code

- Male visitors must wear a shirt and long trousers/jeans. Shorts and sleeveless shirts must be avoided.
- Clothes displaying offensive/objectionable writings/drawings/pictures must be avoided.
- Visible tattoos and piercings must be avoided.

تعليمات ملابس الزائرات من الإناث:

- يتوجب على الزائرات ارتداء ثياب محتشمة مع مراعاة ارتداء القمصان/البلوزات ذات أكمام طويلة والتنانير الطويلة أو الفضفاضة أو الفساتين الواسعة والطويلة.
- يجب تجنب ارتداء الشورت والتنانير القصيرة والقمصان بلا أكمام أو المنخفضة.
- يجب تجنب الملابس الضيقة أو الشفافة أو القصيرة أو الفاضحة أو التي تعرض الخصر أو الورك أو الساقين.
- يجب تجنب الملابس التي تعرض كتابات أو رسومات أو صور مسيئة أو مخلة أو تعتبر غير مقبولة.
- يجب تجنب إبراز الوشوم والحلق فيما عدا حلق الأذن والحناء.

Female Visitors Dress Code

- Female visitors must dress conservatively wearing long-sleeved shirts/blouses with long and loose fitting skirts/slacks, or a long-sleeve loose fitting long dress.
- Shorts, short skirts and sleeveless/low-cut neckline shirts must be avoided.
- Clothing that is tight, transparent, or short and shows too much skin or exposes the waist, back, or legs must be avoided.
- Clothes displaying offensive/objectionable writings/drawings/pictures must be avoided.
- Visible tattoos and piercings must be avoided. This does not include generally acceptable items such as earrings and henna.

4 Local and National Organizing Committees

Local Organizing Committee

Dr Hamid Abderrahmane, Khalifa University, Abu Dhabi, UAE.
hamid.abderrahmane@ku.ac.ae

Dr Afshin Goharzadeh, Khalifa University, Abu Dhabi.
afshin.goharzadeh@ku.ac.ae

Dr Yap Yit Fatt, Khalifa University, Abu Dhabi.
yap.fatt@ku.ac.ae

Dr Peter Corridon, Khalifa University, Abu Dhabi, UAE.
Peter.Corridon@ku.ac.ae

Dr MD Didarul Islam, Khalifa University, Abu Dhabi, UAE.
didarul.islam@ku.ac.ae

Dr Immanuvel Paul, Khalifa University, Abu Dhabi, UAE.
immanuvel.paul@ku.ac.ae

Dr Marwan El Rich, Khalifa University, Abu Dhabi, UAE.
marwan.elrich@ku.ac.ae

National Organizing Committee

Dr Youssef Belhamadia, American University of Sharjah, Sharjah, UAE.
ybelhamadia@aus.edu

Dr Hassan Ali, School of Chemical Engineering, University of Birmingham Dubai, UAE.
h.a.ali.1@bham.ac.uk

5 Program Schedule

Time	Thursday 6th November 2025
7:30 - 8:15	Registration
8:15 - 8:30	Opening Ceremony (B00055)
8:30 - 9:00	**Invited Lecture 1**: Microfluidic Paper Based Analytical Devices (Prof Sunil Kumar, NYU Abu Dhabi) (B00055)
9:00 - 9:30	**Invited Lecture 2**: Bridging The Gap: From Research to Value Realization and Real-World Impact (Dr Ahmad Mourad, Transmed) (B00055)
9:30 - 10:00	Coffee Break & **Poster Session** (Spin Area)
10:00 - 12:00	**Parallel Sessions**: 1A (B00055) and 1B (B00107)
12:00 - 14:00	Photo Session & Lunch (KU Food Court, ground floor Building E, Market Place)
14:00 - 14:30	**Invited Lecture 3**: Oxygen Deficiency Drives Drastic Pattern Transition in Algal Bioconvection (Dr Azam Gholami, NYU Abu Dhabi) (B00055)
14:30 - 15:00	**Invited Lecture 4**: Invariant Manifold Dynamics and Spacecraft Trajectory Design (Dr Elena Fantino, KU) (B00055)
15:00 - 15:30	Coffee Break & **Poster Session** (Spin Area)
15:30 - 17:10	**Parallel Sessions**: 2A (B00055) and 2B (B00107)

Time	Friday 7th November 2025
8:30 - 9:00	**Invited Lecture 5**: Exploiting Multi-Scale Dynamics in Reacting Flows (Prof Dimitris Goussis, KU) (B00055)
9:00 - 9:30	**Invited Lecture 6**: Fluid and Solid Mechanics in Food Technology: Where Science Meets Art (Dr Sergey Melnikov, IFFCO Group) (B00055)
9:30 - 9:45	Coffee Break (Spin Area)
9:45 - 11:45	**Parallel Sessions**: 3A (B00055) and 3B (B00107)
11:45 - 12:00	Closing Ceremony (B00055)

Thursday 6th November 2025, Parallel Session 1A (Fluid Mechanics) (B00055) Chair: Dr Hassan Ali	
10:00-10:20	STAM 2025-02-O: Shock–Vortex Dynamics and Mixing in Fin Assisted Elliptical Jet in Crossflow at Mach 2. *by Alhanouf Eshtairy**
10:20-10:40	STAM 2025-03-O: Passive Ventilation via Origami-Driven Stack Effect *by Zueter A.F. *, Dalaq A.S. & Daqaq M.F.*
10:40-11:00	STAM 2025-36-O: Multi-resolution DMD Analysis of Swirling Spray Dynamics under Flowrate and Ethanol Blending Effects *by Ibrahim Alsafadi*, Afshin Goharzadeh & Hamid Ait Abderrahmane*
11:00-11:20	STAM 2025-21-O: Two- and Three-dimensional Simulations on the Improved Aerodynamic Efficiency due to Partial Heating of Airfoils *by Eman Saddoun*, Bashayer Alhammadi, Hamad Almaeeni, Sultan Alhammadi, Immanuvel Paul & Simon Chingman Yu*
11:20-11:40	STAM 2025-25-O: Aerodynamics and Collection Efficiency of 3D Fog Harvesters *by Ahmed Hisham Shaaban, Md Zishan Akhter, Kamil Jaworczak, Badr Mohamed, Chakravarthy Gudipati & Philip Richard Hart*
11:40-12:00	STAM 2025-26-O: Global Well-Posedness of Three-Dimensional Navier-Stokes Equations with Conservative Forces *by Lo, Assane*, Mama Chacha & Mouhamed M. Fall*

Thursday 6th November 2025, Parallel Session 1B (Bio Mechanics) (B00107) Chair: Dr Marwan El Rich	
10:00-10:20	STAM 2025-07-O: Biomechanical Evaluation of Surrogate Headforms with Ballistic Helmets under High-Velocity Impact *by Atul Harmukh* & Shailesh Ganpule*
10:20-10:40	STAM 2025-13-O: Pressure-Flow Relationships in Micropipettes for High-Precision Single-Cell Studies *by Abolfazl Noh Rouzian & Majid Malboubi**
10:40-11:00	STAM 2025-24-O: Anthropometry and Plantar Pressure Distribution during Gait in Male Subjects: A Novel Approach *by Abdelsalam Tareq Alkhalaileh, Kinda Khalaf, Herbert F. Jelinek & Marwan El Rich**
11:00-11:20	STAM 2025-35-O: Validation of Imbert-Fick Law using Finite Element Analysis and Experimental Testing of Artificial Cornea *by Leo Puthussery Jose*, Nader Vahdati, Marwan El-Rich & Mohamed L Seghier*
11:20-11:40	STAM 2025-38-O: Enhancing Lightweight Universal Talus Implants: The Role of a Compliant Polycarbonate-Urethane Coating in Reducing Contact Pressures *by Ahmed H. Hafez*, Mubinul Islam, Muhammad Mujtaba Syed, Tao Liu & Marwan El-Rich*
11:40-12:00	

Thursday 6th November 2025, Parallel Session 2A (Solid Mechanics) (B00055) Chair: Dr Andreas Schiffer	
15:30-15:50	STAM 2025-05-O: Numerical Investigation of Static and Dynamic Response of Strut-Based Interpenetrating Phase Composites *by Kishor B. Shingare* & Kin Liao*
15:50-16:10	STAM 2025-16-O: Phase Field Modeling of Fracture in Fiber Reinforced Composite Plates *by Shubham Rai* & Badri Prasad Patel*
16:10-16:30	STAM 2025-40-O: Sustainable and Portable Kapok-Based Hydroelectric Generators with High Power Density for Wearable Applications *by Dawei Zhang, Dezhuang Ji, Baosong Li, Xinyu Wang, Abdallah Kamal, Hongtao Zhang, Kin Liao & Lianxi Zheng**
16:30-16:50	STAM 2025-41-O: Low-Speed Impact Response and Shape Memory Effect of Surface-Based Nitinol Lattices *by Mohamad Yassine*, Marwan El Rich & Wael Zaki*

Thursday 6th November 2025, Parallel Session 2B (Fluid/Solid Mechanics) (B00107) Chair: Dr Immanuvel Paul	
15:30-15:50	STAM 2025-44-O: Reliable Production of Small-Scale Microfluidic Features with SLA: Dimensional and Mechanical Insights *by Ayah Al Babouli & Majid Malboubi**
15:50-16:10	STAM 2025-47-O: Structural and Surface Modifications of Cesium Implanted SiC During Annealing in Vacuum and Helium Environments *by H.A.A. Abdelbagi, J.B. Malherbe, A.S. El-Said, T.T. Hlatshwayo & S.S Ntshangase*
16:10-16:30	STAM 2025-48-O: Deformation Analysis of a Coated Aircraft Wing using Fluid-Structure Interface *by Husnain Raza Qasim* & Walid Abou-Hweij*
16:30-16:50	STAM 2025-39-O: TPMS Heat Exchangers for Enhanced Freshwater Production in Humid Environments *by Omar Abdelqader*, Rashid K. Abu Al Rub & Mohamed I. Hassan Ali*
16:50-17:10	STAM 2025-49-O: Numerical Investigation of Flow Dynamics Around a Heated Square Cylinder in Mixed Convection *by Mohd Perwez Ali, Nadeem Hasan & Sanjeev Sanghi*

Friday 7th November 2025, Parallel Session 3A (Fluid Mechanics) (B00055) Chair: Dr Youssef Belhamadia	
9:45-10:05	STAM 2025-30-O: Novel Hierarchical Fractal Geometries for Gypsum Scaling Control in Membrane Distillation: Computational Fluid Dynamics Approach *by Balsam Swaidan*, Immanuvel Paul & Simon Ching Man Yu*
10:05-10:25	STAM 2025-31-O: Spectral Signatures and Inter-Scale Dynamics of Non-Kolmogorov Single-Bubble Turbulence *by Majeed N.J.*, Paul I. & Yu S.C.M.*
10:25-10:45	STAM 2025-34-O: Inherent Thermodynamic Performance Assessment of a Variable Refrigerant Flow System under Transient Cooling Load: A Case Study of an Eco-Villa *by Muhammad Reshaeel & Mohamed I. Hassan Ali**
10:45-11:05	STAM 2025-15-O: Large-Eddy Simulation of a Mach 6 Hypersonic Intake Mode: Toward Predictive Modeling of Unstart *by Kan Wang, Vinayak Rajan, Karthik Subramani & Brett Bornhoft*
11:05-11:25	STAM 2025-37-O: Bio-Inspired V-Formations for Low-Speed Micro Aerial Vehicles *by Abikrishnaa Parimelalagan* & Majid Hassan Khan*
11:25-11:45	STAM 2025-43-O: Droplet Deposition into a Circular Hole with Sharp/Rounded Edge *by Zhang Haokun*, Guan Qiangshun, MD Didarul Islam, Nader Vahdati, Firas Jarrar & Yap Yit Fatt*

Friday 7th November 2025, Parallel Session 3B (Fluid Mechanics) (B00107) Chair: Dr MD Didarul Islam	
9:45-10:05	STAM 2025-09-O: Nanoscale Taylor-Aris Dispersion and Slip Effects in Hybrid Nanochannels *by Mehdi Neek-Amal*
10:05-10:25	STAM 2025-11-O: Numerical Investigation of Optimum Parameters for Two Different TPMS Inserts in Heat Transfer Applications *by Ranjit J. Singh*, Sanjairaj Vijayavenkataraman & Sunil Kumar*
10:25-10:45	STAM 2025-19-O: Computational Study of Heat Transfer Augmentation in Rectangular Channel with Upper Wall Exposed to Constant Heat Flux *by Abed Mennad**
10:45-11:05	STAM 2025-20-O: Nano-Enhanced Thermal Storage Panels for Cubesats using Phase Change Materials: Computational Design, Physics, and Reduced-Order Modeling *by Reema Razak*, Immanuvel Paul & Simon Ching Man Yu*
11:05-11:25	STAM 2025-22-O: Study Heat Transfer through Fins for Heat Pipe in CubeSat Application *by Yousuf El Chihabi, Md. Islam*, Yap Fatt & Firas Jarrar*
11:25-11:45	STAM 2025-28-O: Spectral Management in Hybrid Photovoltaic Thermal Systems: A Thermofluid Dynamics Approach *by Mohit Barthwal & Dibakar Rakshit**

Thursday 6th November 2025, Poster Session (Spin Area)	
9:30 - 10:00 & 15:00 - 15:30	STAM 2025-06-P: Numerical Simulation of a Micromixer with Semi-Circular Obstructions to Mix Blood Plasma and DI Water *by Morteza Bayareh*, Narges Jafari Ghahfarokhi & Haneen Ahmed Sahib Al-Hachami* STAM 2025-23-P: Thermofluidic Spectral Filtering for Hybrid Photovoltaic–Photothermal Conversion *by Mohit Barthwal*, Richard J. Fontenot, Dibakar Rakshit & Daniel J Preston* STAM 2025-33-P: Nondestructive Evaluation of Artificial Bone Using Highly Nonlinear Solitary Waves *by Mariam Barakat*, Tae-Yeon Kim & Andreas Schiffer* STAM 2025-45-P: Relationship between Reynolds Number and Flow-Induced Vibrations in Pipelines *by Mohamed Alfazari, Mohammed Almahri, Abdulrahman Al Ali & Mohamed Fawzy** STAM 2025-46-P: Modelling and Simulation of Cryogenic Liquid CO2 Pipeline Transportation Systems for Arid Environments *by Mohamed Fawzy, Meera Alkhyeli, Hessa Almarri, Salama Alhajri & Meera Alzaabi*

6 Invited Lectures

Lecture 1: Microfluidic Paper Based Analytical Devices

Sunil Kumar
New York University Abu Dhabi, UAE
sunil.kumar@nyu.edu

Abstract
Microfluidic paper-based analytical devices (microPADs) are revolutionizing point-of-care testing, offering simple, low-cost diagnostic platforms. These devices are created by patterning hydrophobic barriers onto paper to form fluid channels, often using lithographic or other established protocols. Unlike conventional microfluidics, microPADs leverage the intrinsic capillary action of paper, eliminating the need for bulky supporting equipment like pumps and power sources. This inherent simplicity, combined with miniaturization and faster response times, unlocks new potential for low-cost, portable diagnostics across fields such as food safety, environmental monitoring, drug screening, and clinical diagnosis. This presentation will detail the modeling, analysis, and recent advances in the fabrication methods of microPADs, highlighting their comparative advantages.

Biography

Dr. Sunil Kumar is a Professor of Mechanical Engineering at New York University Abu Dhabi (NYUAD). He was the founding Dean of Engineering at NYUAD since 2009 until 2015, and from 2015 to 2020 the inaugural Vice Provost for Graduate and Postdoctoral Programs. Before joining NYUAD he was a Professor of Mechanical Engineering and the Dean of the Graduate School at New York University Tandon School of Engineering in Brooklyn, New York, USA. He also previously held the positions of Department Head of Mechanical, Aerospace, Manufacturing Engineering and co-Director of Energy Systems Lab. He joined New York University School of Engineering in 1990.

Prof. Kumar received his PhD in Mechanical Engineering from the University of California at Berkeley, MS in Mechanical Engineering and MA in Mathematics from the State University of New York at Buffalo, and a BTech (Hons) from the Indian Institute of Technology at Kharagpur. His areas of research are energy systems, fire dynamics, thermal and solar radiation, and the use of lasers and optics for sensing. He is a Fellow of the American Society of Mechanical Engineers and a member of The Mohammed bin Rashid Academy of Scientists.

Lecture 2: Bridging The Gap: From Research to Value Realization and Real-World Impact

Ahmad Mourad
Transmed, Abu Dhabi, UAE.
Ahmad.Mourad@transmed.com

Abstract
The journey from academic research and innovation to successful industry application is a universal challenge. While academic and R&D environments are engines of discovery, translating these innovation and ideas into commercially viable products requires navigating a complex landscape of market demands, skills, complexities, and partnerships.

Drawing on practical experience, this non-traditional session suggests a roadmap for bridging this divide. Key topics will include unstoppable trends, aligning research and innovation management with unmet needs and market opportunities, fostering effective collaborations, and managing the lifecycle. Attendees will gain insights into the unstoppable trends and how to position their research for success, ensuring their work not only advances knowledge but also delivers tangible value realization and real-world impact.

Biography

Dr. Ahmad Mourad, Chief Information Officer, Transmed, is an accomplished business and technology leader with 25+ years of corporate international experience working for the private and public sectors driving business value and results. Track record of capabilities building, frameworks, processes, and business models development. Compassionate educator and mentor inspiring and developing corporate leaders and academic scholars. Committed to building and fostering communities of learning in the classroom and beyond. Enable and support the intersection between academia, research and corporate for practical learning, application, growth and societal impact.

Lecture 3: Oxygen Deficiency Drives Drastic Pattern Transition in Algal Bioconvection

Azam Gholami
New York University Abu Dhabi, UAE.
ag9141@nyu.edu

Abstract
Suspensions of motile microorganisms can spontaneously form large-scale fluid motion, known as bioconvection, characterized by dense downwelling plumes separated by broad upwelling regions. In this study, we investigate bioconvection in shallow suspensions of Chlamydomonas reinhardtii confined within spiral-shaped boundaries, combining detailed experiments with three-dimensional simulations. Under open liquid–air interfaces, cells accumulate near the surface via negative gravitaxis, generating spiral-shaped density patterns that subsequently fragment into lattice-like clusters, leading to plume formation. Space–time analyses demonstrate coherent rotational dynamics, with predominantly inward-directed motion near the spiral core and bidirectional motion further out. Introducing confinement by sealing the upper boundary with an air-impermeable wall triggers dramatic pattern transitions due to oxygen depletion: initially stable arrangements reorganize into new structures with significantly reduced wavelengths. Complementary numerical simulations, based on incompressible Navier–Stokes equations incorporating negative buoyancy and active swimmer stress, successfully replicate initial pattern formation, subsequent instability, fragmentation into plumes, and emergence of strong vortical flows—nearly an order of magnitude faster than individual cell swimming. However, these models do not capture oxygen depletion-driven transitions observed experimentally. Our results highlight that geometric confinement, oxygen availability, and metabolic transitions critically regulate bioconvection dynamics, offering novel strategies for controlling microbial self-organization and fluid transport.

Biography

Dr Azam Gholami earned her PhD in Physics from LMU Munich and has been an Associate Professor of Physics at NYU Abu Dhabi since 2022. Her research focuses on active matter and soft-matter hydrodynamics—how simple physical rules generate complex, self-organized patterns in living and synthetic systems. Current topics include the collective behavior of cells, microswimmer physics (cilia/flagella dynamics, bioconvection), reaction–diffusion–advection processes (chemotaxis, wave guidance), and interfacial flows such as Marangoni-driven instabilities in thin films and droplets. Her group combines continuum theory with numerical simulation and experiments (high-speed imaging, particle tracking) to connect mechanisms with transport, mixing, and control, with applications to biotransport, environmental flows, and soft robotic actuation.

Lecture 4: Invariant Manifold Dynamics and Spacecraft Trajectory Design

Elena Fantino
Department of Aerospace Engineering, Khalifa University, Abu Dhabi, UAE.
elena.fantino@ku.ac.ae

Abstract
From the resonance hopping of comets influenced by Jupiter to the deployment of cutting-edge space telescope missions, dynamical systems theory provides a powerful framework for analyzing the motion of celestial bodies within the solar system and has proven instrumental in calculating efficient spacecraft trajectories to a wide range of destinations.

Following a concise introduction to the circular restricted three-body problem, the presentation will delve into recent advancements in the use of libration point orbits and invariant manifolds for spacecraft trajectory design.

Biography

Dr. Fantino holds a degree in Astronomy and earned her Ph.D. in Space Sciences and Space Technologies from the University of Padua, Italy. Her career spans both industry and academia, with expertise in astrodynamics and celestial mechanics, space mission analysis, space geodesy, and astrometry. She has actively contributed to numerous research and development initiatives led by the Italian Space Agency and the European Space Agency. The main focus of her research is the design of trajectories for deep space missions leveraging the dynamical structures of the three-body problem and low-thrust propulsion.

Lecture 5: Exploiting Multi-Scale Dynamics in Reacting Flows

Dimitris Goussis
Department of Mechanical and Nuclear Engineering, Khalifa University, Abu Dhabi, UAE.
dimitris.goussis@ku.ac.ae

Abstract

The dynamics of the governing equations simulating reacting flows incorporate a relatively narrow spectrum of time scales characterizing the action of transport (convection and diffusion), but a very wide range of time scales characterizing the action of chemistry. This is shown convincingly in the displayed figure (from Mass and Pope, C&F 1992).

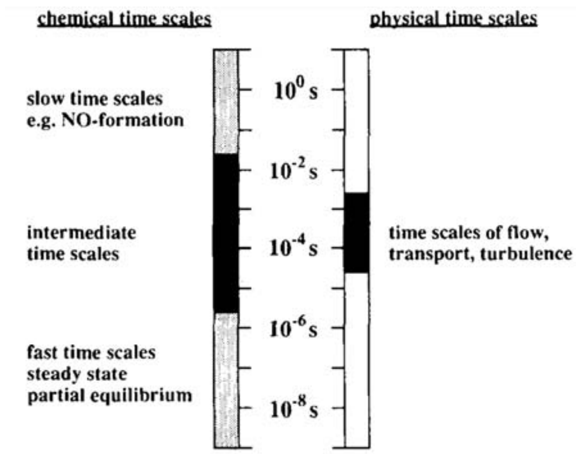


Fig. 1. Schematical illustration of the time scales governing a chemically reacting flow.

Despite the significant advances in CFD during the 70s and the 80s, the wide spectrum of chemical time scales prohibited the consideration of real chemistry in CFD codes, due to the significant stiffness that was introduced. A significant step in incorporating real chemistry effects was recorded in the mid 80s, when asymptotics were employed for the construction of simplified (non-stiff) chemical kinetics mechanisms.

Initially, these mechanisms were created by applying the Quasi Steady-State approximation for the species considered fast. However, since this methodology was relaying on the experience and intuition of the investigator, the improvement was limited. As a result, several algorithmic methodologies were introduced in order to carry-out asymptotics and produce simplified mechanisms; notably the CSP algorithm, which inspired many application-oriented ones, such as ILDM and G-Scheme. These issues will be reviewed and discussed, with an analysis of illustrative cases. It will be demonstrated that these algorithms not only facilitate the incorporation of realistic chemical effects into CFD codes but also introduce valuable algorithmic tools for acquiring significant physical understanding.

Biography

After obtaining his PhD degree from the Mechanical and Aerospace Engr. Dept. of UCLA in 1986, Dr. Dimitris Goussis joined the Dept. of Mechanical and Aerospace Engr. at Princeton University in the USA and then returned to Greece, where he joined the faculty of the Mechanical Engineering Dept. at the University of Patras and then the faculty of Applied Mathematical and Physical Sciences at the National Technical University of Athens. He joined Khalifa University in 2016.

The major focus of his work is the development of algorithmic methodologies for the acquisition of the essential physical understanding, by analyzing mathematical models related to applications in the fields of combustion, biology, pharmacokinetics, and mechanics. He has participated in a number of research projects funded by the European Commission, NASA, DoE etc.

He is a Fellow of the Combustion Institute.

Lecture 6: Fluid and Solid Mechanics in Food Technology: Where Science Meets Art

Sergey Michailovich Melnikov
IFFCO Group, UAE.
smelnikov@iffco.com

Abstract

Artisanal preparation of food has been powered for centuries by superb knowledge of food ingredients and culinary methods, creativity in flavour combination and artistic presentation of food, as well as solid understanding of food nutrition and safety. Societal shift from artisanal to processed foods was driven by industrialization, enabling mass production, increased convenience, and demand for food affordability. Fluid and solid mechanics (FSM) is integral to processed food technology, governing the behavior of food ingredients during food manufacturing, affecting food processing efficiency, as well as influencing textural and sensory attributes of food, its shelf-life, functionality and safety. FSM principles are guiding food processing equipment development and innovation, and, also, design and manufacturing of innovative packaging that meets consumer demands in terms of convenience, functionality, safety and sustainability. Processed foods supply and distribution, as well as instrumental characterization, sensory perception and digestion of food, are described and tailored by practical implementation of FSM knowledge.

In this presentation, a high-level overview of FSM role in modern processed food industry will be discussed with particular attention to the following topics: personalization of foods, mild processing, affordable nutrition, sustainability, food security and food safety. Finally, a case study on the role of decoupling fat crystallization from emulsification during manufacturing of edible w/o emulsions, which could enable next-generation innovations in processed foods, will be presented and discussed.

Biography

Dr. Sergey Melnikov graduated from Moscow State University with an MSc in Chemistry in 1993. In 1997, he earned a dual PhD in Polymer Chemistry from Moscow State University and Biophysical Chemistry from Nagoya University. He then joined Lund University as a postdoctoral fellow.

Since 1999, Dr. Melnikov has built a career in the food and beverage (F&B) industry with global multinational companies including Unilever, Ingredion, IOI Loders Croklaan, and Bunge. Since 2020, he has served as Director of Central R&D, Quality Assurance, Regulatory, and Scientific Affairs at IFFCO Group in the UAE. He brings over 30 years of experience: six years in academic research and nearly 27 years in senior leadership roles at global F&B companies.

Dr. Melnikov is the (co)author of more than 20 patents and patent applications, over 30 peer-reviewed journal publications, and three book chapters.

7 List of Oral Presentation Abstracts

- STAM 2025-02-O: Shock–Vortex Dynamics and Mixing in Fin Assisted Elliptical Jet in Crossflow at Mach 2. *by Alhanouf Eshtairy**
- STAM 2025-03-O: Passive Ventilation via Origami-Driven Stack Effect *by Zueter A.F. *, Dalaq A.S. & Daqaq M.F.*
- STAM 2025-05-O: Numerical Investigation of Static and Dynamic Response of Strut-Based Interpenetrating Phase Composites *by Kishor B. Shingare* & Kin Liao*
- STAM 2025-07-O: Biomechanical Evaluation of Surrogate Headforms with Ballistic Helmets under High-Velocity Impact *by Atul Harmukh* & Shailesh Ganpule*
- STAM 2025-09-O: Nanoscale Taylor-Aris Dispersion and Slip Effects in Hybrid Nanochannels *by Mehdi Neek-Amal*
- STAM 2025-11-O: Numerical Investigation of Optimum Parameters for Two Different TPMS Inserts in Heat Transfer Applications *by Ranjit J. Singh*, Sanjairaj Vijayavenkataraman & Sunil Kumar*
- STAM 2025-13-O: Pressure-Flow Relationships in Micropipettes for High-Precision Single-Cell Studies *by Abolfazl Noh Rouzian & Majid Malboubi**
- STAM 2025-15-O: Large-Eddy Simulation of a Mach 6 Hypersonic Intake Mode: Toward Predictive Modeling of Unstart *by Kan Wang, Vinayak Rajan, Karthik Subramani & Brett Bornhoft*
- STAM 2025-16-O: Phase Field Modeling of Fracture in Fiber Reinforced Composite Plates *by Shubham Rai* & Badri Prasad Patel*
- STAM 2025-19-O: Computational Study of Heat Transfer Augmentation in Rectangular Channel with Upper Wall Exposed to Constant Heat Flux *by Abed Mennad**
- STAM 2025-20-O: Nano-Enhanced Thermal Storage Panels for Cubesats using Phase Change Materials: Computational Design, Physics, and Reduced-Order Modeling *by Reema Razak*, Immanuvel Paul & Simon Ching Man Yu*
- STAM 2025-21-O: Two- and Three-dimensional Simulations on the Improved Aerodynamic Efficiency due to Partial Heating of Airfoils *by Eman Saddoun*, Bashayer Alhammadi, Hamad Almaeeni, Sultan Alhammadi, Immanuvel Paul & Simon Chingman Yu*
- STAM 2025-22-O: Study Heat Transfer through Fins for Heat Pipe in CubeSat Application *by Yousuf El Chihabi, Md. Islam*, Yap Fatt & Firas Jarrar*
- STAM 2025-24-O: Anthropometry and Plantar Pressure Distribution during Gait in Male Subjects: A Novel Approach *by Abdelsalam Tareq Alkhalaileh, Kinda Khalaf, Herbert F. Jelinek & Marwan El Rich**
- STAM 2025-25-O: Aerodynamics and Collection Efficiency of 3D Fog Harvesters *by Ahmed Hisham Shaaban, Md Zishan Akhter, Kamil Jaworczak, Badr Mohamed, Chakravarthy Gudipati & Philip Richard Hart*
- STAM 2025-26-O: Global Well-Posedness of Three-Dimensional Navier-Stokes Equations with Conservative Forces *by Lo, Assane*, Mama Chacha & Mouhamed M. Fall*
- STAM 2025-28-O: Spectral Management in Hybrid Photovoltaic Thermal Systems: A Thermofluid Dynamics Approach *by Mohit Barthwal & Dibakar Rakshit**
- STAM 2025-30-O: Novel Hierarchical Fractal Geometries for Gypsum Scaling Control in Membrane Distillation: Computational Fluid Dynamics Approach *by Balsam Swaidan*, Immanuvel Paul & Simon Ching Man Yu*
- STAM 2025-31-O: Spectral Signatures and Inter-Scale Dynamics of Non-Kolmogorov Single-Bubble Turbulence *by Majeed N.J.*, Paul I. & Yu S.C.M.*

- STAM 2025-34-O: Inherent Thermodynamic Performance Assessment of a Variable Refrigerant Flow System under Transient Cooling Load: A Case Study of an Eco-Villa *by Muhammad Reshaeel & Mohamed I. Hassan Ali**
- STAM 2025-35-O: Validation of Imbert-Fick Law using Finite Element Analysis and Experimental Testing of Artificial Cornea *by Leo Puthussery Jose*, Nader Vahdati, Marwan El-Rich & Mohamed L Seghier*
- STAM 2025-36-O: Multi-resolution DMD Analysis of Swirling Spray Dynamics under Flowrate and Ethanol Blending Effects *by Ibrahim Alsafadi*, Afshin Goharzadeh & Hamid Ait Abderrahmane*
- STAM 2025-37-O: Bio-Inspired V-Formations for Low-Speed Micro Aerial Vehicles *by Abikrishnaa Parimelalagan* & Majid Hassan Khan*
- STAM 2025-38-O: Enhancing Lightweight Universal Talus Implants: The Role of a Compliant Polycarbonate-Urethane Coating in Reducing Contact Pressures *by Ahmed H. Hafez*, Mubinul Islam, Muhammad Mujtaba Syed, Tao Liu & Marwan El-Rich*
- STAM 2025-39-O: TPMS Heat Exchangers for Enhanced Freshwater Production in Humid Environments *by Omar Abdelqader*, Rashid K. Abu Al Rub & Mohamed I. Hassan Ali*
- STAM 2025-40-O: Sustainable and Portable Kapok-Based Hydroelectric Generators with High Power Density for Wearable Applications *by Dawei Zhang, Dezhuang Ji, Baosong Li, Xinyu Wang, Abdallah Kamal, Hongtao Zhang, Kin Liao & Lianxi Zheng**
- STAM 2025-41-O: Low-Speed Impact Response and Shape Memory Effect of Surface-Based Nitinol Lattices *by Mohamad Yassine*, Marwan El Rich & Wael Zaki*
- STAM 2025-43-O: Droplet Deposition into a Circular Hole with Sharp/Rounded Edge *by Zhang Haokun*, Guan Qiangshun, MD Didarul Islam, Nader Vahdati, Firas Jarrar & Yap Yit Fatt*
- STAM 2025-44-O: Reliable Production of Small-Scale Microfluidic Features with SLA: Dimensional and Mechanical Insights *by Ayah Al Babouli & Majid Malboubi**
- STAM 2025-47-O: Structural and Surface Modifications of Cesium Implanted SiC During Annealing in Vacuum and Helium Environments *by H.A.A. Abdelbagi, J.B. Malherbe, A.S. El-Said, T.T. Hlatshwayo & S.S Ntshangase*
- STAM 2025-48-O: Deformation Analysis of a Coated Aircraft Wing using Fluid-Structure Interface *by Husnain Raza Qasim* & Walid Abou-Hweij*
- STAM 2025-49-O: Numerical Investigation of Flow Dynamics Around a Heated Square Cylinder in Mixed Convection *by Mohd Perwez Ali, Nadeem Hasan & Sanjeev Sanghi*

8 List of Poster Presentation Abstracts

- STAM 2025-06-P: Numerical Simulation of a Micromixer with Semi-Circular Obstructions to Mix Blood Plasma and DI Water *by Morteza Bayareh*, Narges Jafari Ghahfarokhi & Haneen Ahmed Sahib Al-Hachami*
- STAM 2025-23-P: Thermofluidic Spectral Filtering for Hybrid Photovoltaic–Photothermal Conversion *by Mohit Barthwal*, Richard J. Fontenot, Dibakar Rakshit & Daniel J Preston*
- STAM 2025-33-P: Nondestructive Evaluation of Artificial Bone Using Highly Nonlinear Solitary Waves *by Mariam Barakat*, Tae-Yeon Kim & Andreas Schiffer*
- STAM 2025-45-P: Relationship between Reynolds Number and Flow-Induced Vibrations in Pipelines *by Mohamed Alfazari, Mohammed Almahri, Abdulrahman Al Ali & Mohamed Fawzy**
- STAM 2025-46-P: Modelling and Simulation of Cryogenic Liquid CO2 Pipeline Transportation Systems for Arid Environments *by Mohamed Fawzy, Meera Alkhyeli, Hessa Almarri, Salama Alhajri & Meera Alzaabi*

STAM 2025-02-O: Shock–Vortex Dynamics and Mixing in Fin Assisted Elliptical Jet in Crossflow at Mach 2.

Alhanouf Eshtairy[1,2]
[1] Cranfield University, Bedfordshire, UK
[2] Technology Innovation Institute, Abu Dhabi, UAE
*Alhanouf.eshtairy@tii.ae

Keywords
jet-in-crossflow, SWBLI, CRV, Q-criterion, turbulent mixing

Abstract

We interrogate instability and turbulence mechanisms governing air–hydrogen mixing for sonic elliptical jets (golden-ratio aspect) in a Mach 2.4 crossflow. Building on steady RANS predictions, DDES exposes time resolved shock–boundary layer interactions (SWBLI), counter rotating vortex pairs CRVs, and shock induced unsteadiness that control hydrogen dispersion. An upstream fin strengthens streamwise vorticity driving greater jet penetration and circulation while incurring a small pressure recovery penalty. Quantitative metrics (η_{mixing}, Z/D, Γ) and Q-criterion visualization where coherent structures amplify mixing and where they decay. The analysis clarifies how shocks couple with barrel shock/Mach disk and vortices topology to enhance mixing. These insights provide physics-based guidelines to tune injector orientation and passive control for mixing in hypersonic combustors. *Prior dissemination note: new content centers on unsteady shock–vortex topology and fin induced instability dynamics beyond the earlier talk.*

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-03-O: Passive Ventilation via Origami-Driven Stack Effect

Zueter A.F.[1*], Dalaq A.S.[2], Daqaq M.F.
[1]1Department of Mechanical Engineering, New York University Abu Dhabi, Abu Dhabi, United Arab Emirates
[2]2Department of Bioengineering, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia
*ahmad.zueter@nyu.edu

Keywords
Passive ventilation, Kresling origami, Sustainable ventilation

Abstract

This study introduces a passive system using stack-effect ventilation enhanced by deployable Kresling origami elements (SKEs) mounted on chimneys or ducts. These elements expand or contract to adjust chimney height and airflow with minimal energy. Performance was evaluated using full-scale 3D RANS simulations with temperature-dependent buoyancy, alongside an analytical model based on the first law of thermodynamics. Different geometric configurations—panel number and aspect ratio—were tested. Results show SKEs can boost ventilation by ~30–50% when doubling or tripling duct height under ≥20 °C indoor-outdoor temperature differences. A six-panel, 0.75 aspect ratio design achieves a fivefold airflow variation between contracted and expanded states. Higher aspect ratios and more panels reduce viscous losses. This work highlights origami structures as adaptive, low-energy ventilation regulators for both mining and residential applications. Future efforts will optimize SKE geometry to cut flow resistance and integrate heat recovery systems for combined thermal and airflow control.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-05-O: Numerical Investigation of Static and Dynamic Response of Strut-Based Interpenetrating Phase Composites

Kishor B. Shingare[1,2,*] & Kin Liao[1,2]
[1]Department of Aerospace Engineering, Khalifa University of Science & Technology, 127788, Abu Dhabi, United Arab Emirates.
[2]Research & Innovation Center for Graphene and 2D Materials (RIC-2D), 127788 Abu Dhabi, United Arab Emirates.
*kishor.shingare@ku.ac.ae

Keywords
Interpenetrating Phase Composites, Struts, RVE, Finite Element Methods, Polymers.

Abstract

Interpenetrating Phase Composites (IPCs) are an advanced class of materials in which two or more continuous phases coexist within an interconnected architecture, enabling superior load transfer and multifunctional performance compared to traditional composites. This study presents a finite element–based investigation of the static and dynamic mechanical behavior of polymer/polymer IPCs with various strut-based lattice topologies, including simple cubic, octet, diamond, and pyramid configurations. A Representative Volume Element (RVE) framework is employed to simulate compressive loading and extract key performance metrics such as stiffness, strength, energy absorption, and Poisson's ratio. Special attention is given to the emergence of auxetic (negative Poisson's ratio) responses in certain architectures, which highlight their potential for impact-resistant and energy-dissipating applications. The results demonstrate that lattice topology plays a significant role in dictating the balance between stiffness and energy absorption, with some IPC designs offering enhanced multifunctionality. The insights gained from this work provide a scientific basis for the design and optimization of lightweight, resilient, and application-specific IPC structures, with relevance to both engineering and biomedical systems.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-06-P: Numerical Simulation of a Micromixer with Semi-Circular Obstructions to Mix Blood Plasma and DI Water

Morteza Bayareh[1,*], Narges Jafari Ghahfarokhi[2], Haneen Ahmed Sahib Al-Hachami[1]
[1]Department of Mechanical Engineering, Shahrekord University, Shahrekord, Iran
[2]Department of Mechanical Engineering, University of Isfahan, Isfahan, Iran
*m.bayareh@sku.ac.ir

Keywords
Microfluidics, Micromixer, Blood plasma, DI water

Abstract

Micromixers are important devices in microfluidics designed for mixing liquids on a micro-scale. These devices are crucial in chemistry, pharmaceuticals, analytical chemistry, biochemistry, and high-throughput synthesis due to their ability to precisely manage small volumes of liquids. In the present work, the mixing process in five converging-diverging micromixers is examined. Results demonstrate that in the base case, with an increase in velocity from 0.001 to 1 m/s, the mixing index increases from 20.82% to 56.43%. In the first case, with an increase in inlet velocity, the size of the vortices formed behind the obstacles increases, and the mixing quality improves. In the second case, with an increase in inlet velocity and the larger size of the vortices formed in front of the obstacles and their influence, the mixing quality significantly increases. In the third case, due to the circular chambers and the formation of larger vortices, the mixing index slightly increases with the increase in inlet velocity. In the fourth case, the increase in efficiency with the increase in inlet velocity is very small. The reason for the negligible increase in the mixing index is the small contact area between the two fluids, which the circular obstacles do not allow.

Oral Presentation	
Poster Presentation	**selected**

STAM 2025-07-O: Biomechanical Evaluation of Surrogate Headforms with Ballistic Helmets under High-Velocity Impact

Atul Harmukh[1*], Shailesh Ganpule[1, 2]
[1]Department of Mechanical and Industrial Engineering, Indian Institute of Technology, Roorkee, India, 247667
[2]Department of Design, Indian Institute of Technology, Roorkee, India, 247667
*atul_h@me.iitr.ac.in

Keywords
high velocity bullet impact, ballistic helmet, biomechanical parameters, headforms

Abstract

High velocity bullet impact (bullet velocity: 700 ± 15 m/s) pose a critical threat to head and neck safety in modern combat scenarios, often resulting in severe traumatic injuries. Despite this fact, ballistic helmets designed explicitly to counter such a threat are either unavailable, or their effectiveness has not been evaluated. In this work, we have investigated the ballistic performance of two newly developed ballistic helmet configurations under high velocity bullet impact: (a) Patka helmet, constructed from hardened steel, and (b) advanced helmets incorporating a ceramic polymer sandwich plate integrated onto a Kevlar and UHMWPE shell. Three instrumented headforms were used to measure biomechanical parameters including back face deformation (BFD), head inematics, neck loads, and brain pressure. While both helmets successfully stopped the bullet, the Patka helmet exhibited minimal BFD (<1 mm), but biomechanical parameters like angular acceleration (~5800 rad/s²) and neck force (~250 N) exceeded mild TBI thresholds, posing a risk of injury. The advanced helmets showed BFD between 7-9 mm, within acceptable limits, but had higher angular acceleration (~6500 rad/s²), neck force (~2000 N), and coup pressure (~300 kPa), suggesting a higher risk of serious injury. These results underscore that BFD alone does not reliably predict injury risk, emphasizing the need for a more comprehensive evaluation of helmet performance in future designs.

Oral Presentation	**X**
Poster Presentation	

STAM 2025-09-O: Nanoscale Taylor-Aris Dispersion and Slip Effects in Hybrid Nanochannels

Mehdi Neek-Amal[1]
[1]Departement Fysica, Universiteit Antwerpen, Groenenborgerlaan 171, B-2020 Antwerpen, Belgium
*mehdi.neek-amal@uantwerpen.be

Keywords
Taylor-Aris Dispersion, Hybrid nanochannels, Slip length, Energy landscape, Molecular modeling and simulations

Abstract

This talk presents our recent advances in understanding and verifying Taylor-Aris (T-A) dispersion phenomena at nanoscales, focusing on hybrid nanochannels composed of grapheme and other materials. We extend classical dispersion theory by incorporating slip length effects and Peclet number dependencies to develop a generalized enhancement factor for fluid flow in nanofluidic channels. Our approach is rigorously validated by molecular dynamics simulations of two-dimensional Lennard-Jones liquids and angstrom-scale channels involving grapheme and MoS2, elucidating unique transport behaviors of monolayer water and slip-dependent dispersion coefficients [1,2]. Additionally, we introduce a novel simulation methodology to quantify the role of surface energy landscape topology and slip length on T-A dispersion in nanostructured materials such as carbon nanotubes [3]. This comprehensive framework bridges molecular-level slip dynamics and macroscopic dispersion, enabling precise estimation of slip lengths via measured dispersion coefficients. The work provides theoretical and computational foundations with direct implications for nanoscale fluid transport, microfluidic device design, and applications in filtration and advanced materials.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-11-O: Numerical Investigation of Optimum Parameters for Two Different TPMS Inserts in Heat Transfer Applications

Ranjit J. Singh[1*], Sanjairaj Vijayavenkataraman[2], Sunil Kumar3
[1]Division of Engineering, New York University Abu Dhabi, UAE
*rjs9414@nyu.edu

Keywords
Triply Periodic Minimal Surface, Gyroid, Primitive, Flow inserts, Solar Heating

Abstract

Efficient heat transfer between fluids and solid structures is a critical design requirement for compact and high-performance thermal management systems. One widely used strategy involves incorporating inserts within flow channels to augment convective heat transfer while simultaneously enhancing structural stability, particularly under high-temperature and high-pressure conditions. Recently, triply periodic minimal surfaces (TPMS) have gained attention as potential alternatives to conventional inserts due to their unique geometry [1], which offers high surface-to-volume ratios and structural robustness. However, not all TPMS topologies are suitable for heat exchanger applications, as many lack continuous axial fluid passage. Among the viable candidates, the gyroid and primitive TPMS structures provide interconnected pathways that enable efficient flow transport and are therefore promising for integration as a flow insert.

This study presents a comparative numerical investigation of gyroid and primitive TPMS inserts against a baseline rectangular-shaped conduit, as shown in Figure 1. Simulations were performed in ANSYS CFX 2023 under forced convection at a constant Reynolds number of Re = 300, with a uniform surface heat flux of q = 1400 W/m² applied from the top surface. All configurations were constrained to identical cross-sectional areas and axial lengths. For the TPMS cases, axial periodicity was varied as 5π, 7π, and 10π, which modifies the unit cell compartment size and surface area, thereby influencing both the heat transfer and the associated pressure drop. A conjugate heat transfer model was employed to evaluate pressure drop, fluid temperature rise, and heat transfer coefficient across the tested geometries. Results demonstrate that TPMS-based designs can achieve more than double the heat transfer performance of a conventional rectangular design. Notably, the gyroid structure consistently outperformed the primitive configuration, exhibiting nearly threefold higher performance. This superior behavior is attributed to the gyroid's significantly larger fluid volume, more than twice that of the primitive structure for the same axial and cross-sectional dimensions, facilitating enhanced convective transport and heat dissipation.

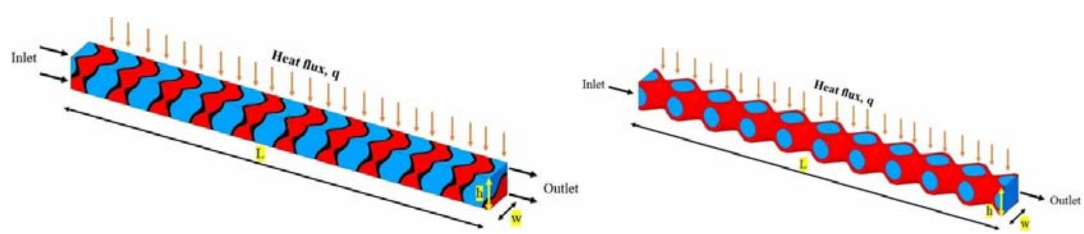


Figure 1: The schematic representation of heat exchanger inserts (a) Gyroid and (b) Primitive

Oral Presentation	selected
Poster Presentation	

STAM 2025-13-O: Pressure-Flow Relationships in Micropipettes for High-Precision Single-Cell Studies

Abolfazl Noh Rouzian[1], Majid Malboubi[2*]
[1] Department of Mechanical Engineering, Isfahan University of Technology
[2] Department of Mechanical Engineering, University of Birmingham Dubai
*m.malboubi@bham.ac.uk

Keywords
Micropipettes, Fluid mechanics, Pressure drop, Microelectrode techniques, Single-cell analysis

Abstract

Glass micropipettes are widely utilized in cell biology and biomedical research for applications such as microinjection, cell aspiration, and patch-clamp electrophysiology. Despite their extensive use, the hydrodynamic behaviour of fluid within micropipettes, particularly the pressure drop at the micron-scale tip, remains an important yet underexplored subject. Understanding these flow dynamics is critical for improving manipulation precision, reducing cell damage, and enhancing reproducibility in single-cell experiments [1, 2]. In this study, we investigate the fluid mechanics of micropipettes through a combination of experimental measurements and numerical simulations. Experimentally, fluorescent microscopy was employed to visualize and quantify flow inside micropipettes under controlled pressure gradients. Careful application of suction and injection pressures revealed the influence of capillary rise on pressure predictions. While deviations from equilibrium capillary rise were significant at very low pressures, their effect diminished under moderate to high pressure differentials, aligning with theoretical expectations of capillary-driven microscale flows. Complementing experiments, Computational Fluid Dynamics (CFD) simulations were conducted in COMSOL Multiphysics. A three-dimensional hydrodynamic model solving the incompressible Navier–Stokes and continuity equations was developed to capture fluid behaviour. The impact of critical design variables, including pipette tip angle, and inlet–outlet diameter ratio, was systematically studied. Simulation results demonstrated strong agreement with experimental data, confirming the accuracy of the model in reproducing pressure–flow relationships. This work highlights the interplay between microscale hydrodynamics and pipette design, offering insights into optimizing micropipette-based techniques. The integration of experimental validation with CFD modelling provides a robust framework for guiding next-generation biomedical tools that require high precision and control at the single-cell level.

Oral Presentation	**X**
Poster Presentation	

STAM 2025-15-O: Large-Eddy Simulation of a Mach 6 Hypersonic Intake Mode: Toward Predictive Modeling of Unstart

Kan Wang[1], Vinayak Rajan[1], Karthik Subramani[1], Brett Bornhoft[1]
[1]Cadence Design Systems, 2655 Seely Ave, San Jose, CA, USA 95134
*ddieu@cadence.com

Keywords
Hypersonic, large-eddy simulation, inlet unstart

Abstract

Hypersonic vehicle operability depends critically on the inlet's susceptibility to unstart. Unstart occurs when downstream blockages or boundary layer separation under off-design conditions destabilize the shock train, causing it to rapidly move upstream through the isolator and exit the intake. This leads to a sharp drag increase and often results in vehicle loss. Predicting unstart is essential for expanding the flight envelope and ensuring vehicle reliability. This study uses large-eddy simulation (LES) to predict on- and off-design conditions in a Mach 5.97 hypersonic intake model developed for the SPICES-4 workshop. Simulations span angles of attack from 0°to 4°, with experimental pressure data available for comparison at 0°,1°,2°, and 3°. The 1.7 m inlet is a 2D external compression inlet using a series of planar ramps to generate shock waves to compress the air before it enters the throat of the inlet. The internal flowpath is rectangular with downstream struts. Pressure distributions from LES are compared to ramp-side probe measurements, with unstart observed experimentally at α=3°. The LES formulation uses a compressible Navier-Stokes solver with the Vreman subgrid-scale model. A hemispherical domain mimics farfield conditions, and inlet boundary conditions are obtained from wind tunnel data. An adiabatic equilibrium wall model is prescribed at all surfaces. This paper presents grid resolution requirements, emphasizing sensitivity in the isolator core. We compare averaged pressure data from simulations to experimental measurements at relevant angles of attack. Results will demonstrate LES's ability to predict unstart events. We analyze the flow dynamics leading to unstart and assess hysteresis effects present in transient conditions. Overall, the study highlights LES as a predictive tool for unstart, essential for off-design intake analysis.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-16-O: Phase Field Modeling of Fracture in Fiber Reinforced Composite Plates

Shubham Rai1*, Badri Prasad Patel1
1Indian Institute of Technology Delhi, Hauz Khas, New Delhi – 110016, India
*shubham.rai@am.iitd.ac.in

Keywords
Phase field method, fiber reinforced composites, arc-length continuation, finite element method

Abstract

Computational modeling of sharp crack interfaces can be done using Phase Field Method (PFM) [1, 2] which regularizes the sharp crack into a diffuse band using a continuously varying phase field variable and a length scale parameter. The length scale parameter controls width of the diffuse band, and evolution of phase field variable is governed by minimization of summation of bulk energy and crack surface energy of the solid.

Crack propagation in fiber reinforced composites is dependent on fiber orientation as it is difficult for the crack to travel perpendicular to fibers. In contrast, crack propagation parallel to fibers is favored because it is easier to fracture matrix compared to fibers [3]. Phase field modeling of fracture in laminated composites is mostly limited to the panels subjected to in-plane loading [4, 5], and the panels subjected to out-of-plane loading are modeled using 3D finite elements [3]. However, 3D finite elements are computationally expensive in case of slender structures such as laminated composite plates. Therefore, a layer-wise phase field framework is developed using an efficient higher order plate theory with thickness stretch and zig-zag terms with quadratic through thickness variation of phase field variable in each layer of the laminated composite plate. The governing equations involving displacement field and phase field are solved alternately using finite element method with load control algorithm before the limit point and arc-length control algorithm after the limit point. An in-depth analysis of the accuracy and efficiency of the developed framework will be presented at the symposium.

Oral Presentation	selected
Poster Presentation	

STAM 2025-19-O: Computational Study of Heat Transfer Augmentation in Rectangular Channel with Upper Wall Exposed to Constant Heat Flux

Abed Mennad
Department of Mechanical Engineering Technology
Higher Colleges of Technology,
Sharjah, United Arab Emirates
*amennad@hct.ac.ae

Keywords
Cooling channel; Ribs; heat transfer augmentation; CFD

Abstract

A computational study of heat transfer augmentation in a rectangular channel having rectangular ribs on the upper wall and triangular ribs on the opposite wall by using Computational Fluid Dynamics (CFD) software (ANSYS FLUENT R18.2) is presented in this work. Effects of Reynolds number on both the flow variables (velocity, pressure, turbulent kinetic energy) and heat transfer variables (temperature and heat transfer coefficient) for three different types of ribs configurations were investigated. The three cases of study are: 1. Ribs Top Smooth Bottom Channel; (RTSBC), 2. Smooth Top Rib Bottom Wall (STRBC) and 3. Ribs Top Rib Bottom Channel (RTRBC). The computation based on finite volume with SIMPLE algorithm has been conducted for air flow in terms of Reynolds number ranging from 4000-20000 has been carried out with SST k-ω turbulence model. It has been found that for Case 1, ribs have negligible effect on heat transfer augmentation and pressure drop, unlike Case 2 where a moderate effect is observed. Maximum values for Nusselt number and friction factor are obtained for Ribs Top Rib Bottom Channel (RTRBC).

References

[1] Jian L, Hussain S, Wang J. Wang L, Xie G. Heat transfer enhancement and turbulent flow in high aspect ratio channel (with ribs of various truncation types and arrangement. International Journal of thermal sciences 123 99-116 (2018)
[2] Sebastian R, Frederick A. Detached eddy simulation of turbulent flow and heat transfer in cooling channels roughened by variously shaped ribs on one wall. International Journal of Heat and Mass Transfer 118 388-401 (2018).
[3] Wang L, Wang S, Wen F, Zhou X, Wang Z. Effects of continuous wavy ribs on heat transfer and cooling air flow in a square single-pass channel of turbine blade. International Journal of Heat and Mass Transfer 121514–533 (2018)

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-20-O: Nano-Enhanced Thermal Storage Panels for Cubesats using Phase Change Materials: Computational Design, Physics, and Reduced-Order Modeling

Reema Razak[1*], Immanuvel Paul[1] & Simon Ching Man Yu[1]
[1]Department of Aerospace Engineering, Khalifa University, Abu Dhabi, United Arab Emirates
*100065870@ku.ac.ae

Keywords
Phase change material, Nano-PCM, CubeSat thermal control, Reduced-order modeling

Abstract

This study presents a comprehensive thermal investigation of multilayered thermal storage panel (TSP) tailored for compact thermal management applications, with a focus on aerospace and solar energy systems. Through a synergistic combination of experimentally-validated high-fidelity transient simulations, and a novel physics-based resistance–capacitance (RC) network model, the influence of phase change materials (PCM), nanoparticle-enhanced PCMs (nano-PCMs), and lattice structures is systematically analyzed. The results demonstrate that nano-PCMs and lattice structures with higher thermal conductivity behave in a way that they have the same latent heat capacity as that of the baseline PCM. A novel RC modeling framework is proposed wherein thermal resistances are derived analytically assuming 1D heat conduction and then rigorously corrected using a physics-based scaling factor, which is justified through volumetric integration of multidimensional heat paths rather than empirical fitting. The final compact RC model shows excellent agreement with full-scale transient simulations, capturing the temperature evolution with a relative error under 5%. This semi-analytical framework is not only computationally efficient but also physically interpretable and extendable to a wide range of multilayered thermal buffer systems. The findings offer a generalized pathway to rapidly screen and optimize PCM integrated architectures for passive thermal control in next-generation satellites, photovoltaic modules, and embedded electronics, thereby bridging the gap between detailed simulations and real-time design demands in applied thermal engineering.

References

[1] T. Liu, Q. Sun, J. Meng, Z. Pan, Y. Tang, Degradation modeling of satellite thermal control coatings 520 in a low earth orbit environment, Solar Energy 139 (2016) 467–474. 521
[2] R. Coker, Thermal modeling in support of the edison demonstration of smallsat networks project, in: 43rd International Conference on Environmental Systems, 2013, p. 3368. 523
[3] B. M. Diaconu, M. Cruceru, L. Anghelescu, Phase change materials in space systems. fundamental applications, materials and special requirements–a review, Acta Astronautica 216 (2024) 163–213.
[4] P. B. Salunkhe, P. S. Shembekar, A review on effect of phase change material encapsulation on the thermal performance of a system, Renewable and sustainable energy reviews 16 (8) (2012) 5603–5616.
[5] P. A. Mirzaei, F. Haghighat, Modeling of phase change materials for applications in whole building 529 simulation, Renewable and Sustainable Energy Reviews 16 (7) (2012) 5355–5362.
[6] Z. Maqbool, M. Hanief, M. Parveez, Review on performance enhancement of phase change material based heat sinks in conjugation with thermal conductivity enhancers for electronic cooling, Journal of Energy Storage 60 (2023) 106591.
[7] R. Baby, C. Balaji, Experimental investigations on phase change material based finned heat sinks for electronic equipment cooling, International Journal of Heat and Mass Transfer 55 (5-6) (2012) 1642–1649.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-21-O: Two- and Three-dimensional Simulations on the Improved Aerodynamic Efficiency due to Partial Heating of Airfoils

Eman Saddoun[1,*], Bashayer Alhammadi[1#], Hamad Almaeeni[1#], Sultan Alhammadi[1#], Immanuvel Paul[1,2], and Simon Chingman Yu[1]

[1]Department of Aerospace Engineering, Khalifa University, Abu Dhabi, United Arab Emirates6
[2]Center for Membranes and Advanced Water Technology (CMAT), Khalifa University, Abu Dhabi, United Arab Emirates
*100065190@ku.ac.ae

Keywords
Bio-inspired, thermal camber, energy-efficient strategy, aerodynamic efficiency.

Abstract

This study investigates a bio-inspired, energy-efficient thermal strategy to enhance airfoil aerodynamics. Moving beyond the established concept of full-surface thermal camber, we propose and optimize a partial heating approach on the lower surface of a NACA 2412 airfoil. Transient computational fluid dynamics (CFD) simulations are conducted using ANSYS Fluent, employing a Detached Eddy Simulation (DES) model to capture the viscous, turbulent flow. The research encompasses a parametric study across various angles of attack and lower-surface heating segments at both low and high Reynolds numbers. Results indicate that selectively heating only a portion of the lower surface can achieve performance gains comparable to full thermal camber, but with substantially lower energy input. A key objective is to determine the minimum required heating duration by analyzing the transient flow development and its effect on aerodynamic performance compared to continuous heating. The analysis reveals that sustained heating is not necessary; a shorter, pulsed heating duration can produce a similar quasi-steady improvement in the lift-to-drag ratio [1].

References

[1] Samiee, A., Djavareshkian, M. H., Feshalami, B. F. & Esmaeilifar, E. Improvement of airfoils aerodynamic efficiency by thermal camber phenomenon at low reynolds number. J. Aerosp. Technol. Manag. 10, e4518 (2018).

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-22-O: Study Heat Transfer through Fins for Heat Pipe in CubeSat Application

Yousuf El Chihabi[1], Md. Islam[1*], Yap Fatt[1] & Firas Jarrar[2]
[1]Mechanical and Nuclear Engineering Department, Khalifa University of Science and Technology, Abu Dhabi, UAE
[2]Department of Mechanical Engineering, Al Hussein Technical University, Jordan
*didarul.islam@ku.ac.ae

Keywords
Heat transfer, Solid fins, Heat pipe, Finite element method, CubeSat, Space radiator

Abstract

Recent advances in computer technologies and manufacturing processes allow us to assemble highly developed components within a compact body such as small-scale satellites (CubeSats). Avionics installed in satellites generate a considerable amount of heat; in addition, during orbit, satellites are exposed to intense solar radiation ranging from direct sunlight, sunlight reflected off Earth (albedo), and infrared (IR) energy emitted from Earth [1]. Hence spacecraft thermal control is a necessity during the design process. Heat pipes are the most common passive thermal management devices used for space application due to their weight penalty, zero maintenance, and reliability [2]. Fins are used to enhance heat transfer; for instance, fins are added to the condenser part of the heat pipe to improve heat rejection. R. J. Naumann[3] developed a method for optimizing the configuration of a heat pipe radiating fins, in terms of heat rejected per radiating mass. The objective of the current study is to model, design, and optimize the radiating solid fins attached on the condenser part of the heat pipe. The numerical study was done using ANSYS Steady State Thermal for copper material. Different fin geometries required different parameter sets; for instance, the rectangular longitudinal fins were parametrized based on three parameters: fin width, fin thickness, and number of fins. In addition, rectangular cross-sectional fins were parametrized with respect to fin width, fin height, fin spacing, and number of fins. For rectangular cross-sectional fins and circular annular fins no improvement has been found in net outgoing radiated heat per unit mass of condenser/fin system. Furthermore, as fin width increases for rectangular longitudinal fins, trapezoidal longitudinal fins, and triangular longitudinal fins elevate. Increasing the number of fins beyond n=3 reduces the heat transfer rate per unit mass.

References:

1. Gilmore, DG DM. Spacecraft Thermal Control Handbook. Volume I, Volume I,. Vol I.; 2002. http://app.knovel.com/hotlink/toc/id:kpSTCHVFT2/spacecraft-thermal-control.
2. Karam R. Satellite Thermal Control for Systems Engineers.; 1998. doi:10.2514/4.866524
3. Naumann RJ. Optimizing the design of space radiators. Int J Thermophys. 2004;25(6):1929-1941. doi:10.1007/s10765-004-7747-0

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-23-P: Thermofluidic Spectral Filtering for Hybrid Photovoltaic–Photothermal Conversion

Mohit Barthwal[1,2,3*], Richard J. Fontenot[3], Dibakar Rakshit[1,2], Daniel J Preston[3]
[1]Indian Institute of Technology Delhi Abu Dhabi, Abu Dhabi, United Arab Emirates
[2]Indian Institute of Technology Delhi, New Delhi, India
[3]Rice University, Houston, TX, USA
*adesz208163@iitdabudhabi.ac.ae

Keywords
Convective heat transfer, Nanofluid thermo-optics, Optical analysis, Spectral beam splitting

Abstract

Photovoltaic (PV) cells are fundamentally constrained by thermalization and absorption losses, effectively converting only a narrow portion of the solar spectrum to electricity [1]. For instance, near-infrared radiation raises cell temperature without providing electrical power, in turn further degrading overall conversion efficiency [2]. To address this opto-thermo-electrical bottleneck, we investigate a nanofluid-based optical filter unit (OFU) that enables selective spectral transmission and volumetric absorption, thereby separating the electrical and thermal conversion pathways. The OFU is constructed using a transparent reservoir filled with spectrally 'intelligent' nanofluid, whose optical extinction coefficients are tailored through Rayleigh scattering theory and controlled particle dispersion. The thermofluidic response of the nanofluid layer is evaluated using coupled temperature-efficiency measurements under AM1.5 solar experiments. Results reveal that the nanofluid filter reduces peak PV temperature while exhibiting a positive fluid-to-PV temperature difference, confirming spectral beam filtering. The PV module maintains an electrical efficiency of ~9%, compared to 6-7% in the bare module case, while simultaneously enabling additional thermal energy recovery at higher fluid temperatures than that of the module. Overall, this work demonstrates how fluid-structure design of transparent enclosures and nanoscale optical tailoring influence coupled heat transfer, light transport, and system efficiency. These findings highlight the role of thermo-fluidic spectral filtering in enabling next-generation hybrid photovoltaic-thermal collectors that can exploit the full solar spectrum.

References

[1] Huang G, Wang K, Markides CN. Efficiency limits of concentrating spectral-splitting hybrid photovoltaic-thermal (PV-T) solar collectors and systems. Light Sci Appl 2021;10:28. https://doi.org/10.1038/s41377-021-00465-1.
[2] Polman A, Atwater HA. Photonic design principles for ultrahigh-efficiency photovoltaics. Nat Mater 2012;11:174–7. https://doi.org/10.1038/nmat3263.

Oral Presentation	
Poster Presentation	**X**

STAM 2025-24-O: Anthropometry and Plantar Pressure Distribution during Gait in Male Subjects: A Novel Approach

Abdelsalam Tareq Alkhalaileh[1], Kinda Khalaf[2], Herbert F. Jelinek[2] & Marwan El Rich[3*]
[1]Khalifa University, Abu Dhabi
[2]Health Care Engineering and Innovation Center
[3]Biotechnology Center
*100062543@ku.ac.ae

Keywords
Plantar Pressure, Anthropometry, Body Shape

Abstract

Plantar pressure signatures provide critical information regarding the foot and lower limb mechanics [1]. Traditionally, research on plantar pressure in male populations has predominantly focused on dividing the plantar surface into two or three regions, considering factors such as body mass index (BMI), age, and gender [2][3]. This study took a more comprehensive approach, incorporating various anthropometric measurements representing body shape, including arm, leg, and shoulder lengths, as well as thigh, chest, waist, hip, and ankle circumferences. Utilizing retrospective data from healthy male subjects, the study yielded results revealing robust correlations with Euclidean measurements, circumferential measurements, and circumferential ratios. Interestingly, while only one significant correlation was found between peak plantar pressure magnitude and location with BMI, significant correlations were seen with the lengths of the upper arm, lower arm, and shoulder ($r>0.80$). In addition, circumferential measurements such as ankle, thigh, and wrist circumferences all correlated significantly as well ($r>0.75$). Incorporating ratios that combined multiple measurements showed promise, with correlation coefficients exceeding 0.82. These findings suggest that a comprehensive plantar pressure analysis should not solely rely on BMI but rather include a thorough examination of subject anthropometry. The results also shed light on the feasibility of developing an index for predicting plantar pressure characteristics based on anthropometric data. Further research and expanded datasets are crucial for refining and validating these findings.

References

1. H. Abdul Razak et al. In Sensors., 2012 DOI: 10.3390/s120709884
2. K. Feka et al. Medicine., 2020 DOI: 10.1097/MD.0000000000021968
3. K. Khalaf et al. Gait and Posture., 2022 DOI: 10.1016/j.gaitpost.2022.09.071

Oral Presentation	selected
Poster Presentation	

STAM 2025-25-O: Aerodynamics and Collection Efficiency of 3D Fog Harvesters

Ahmed Hisham Shaaban[1], Md Zishan Akhter[1], Kamil Jaworczak[1], Badr Mohamed[1], Chakravarthy Gudipati[1], Philip Richard Hart[1]
[1]Renewable and Sustainable Energy Research Center, Technology Innovation Institute, Abu Dhabi, United Arab Emirates
*ahmed.shaaban@tii.ae

Keywords
Atmospheric Water Harvesting, 3D Fog Harvester, Fog Collection, Arid Climates, Sustainable Water Supply

Abstract

Water scarcity remains a critical challenge in arid regions such as parts of Africa and countries with limited natural freshwater resources like the United Arab Emirates, where fog events represent a largely underutilized source of water. Conventional two-dimensional (2D) fog harvesting systems suffer from inherent limitations, including fixed orientation, restricted aerodynamic interaction, modest collection efficiency, and susceptibility to damage under high wind conditions. This study explores alternative three-dimensional (3D) designs aimed at overcoming these challenges and enabling more efficient fog harvesting as a non-conventional water resource. Compared to standard 2D systems, the proposed 3D configurations demonstrate enhanced adaptability, improved aerodynamic performance, and greater water collection potential. These designs were developed using generic modeling approaches and evaluated under varying simulated weather conditions. Results indicate that the new configurations can achieve up to a twofold increase in collection efficiency relative to 2D nets, with consistent performance gains across relevant operating conditions. Further details on the designs and their performance will be presented and discussed.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-26-O: Global Well-Posedness of Three-Dimensional Navier-Stokes Equations with Conservative Forces

Lo, Assane[1*], Mama Chacha[2], Mouhamed M. Fall[3]
[1]University of Wollongong in Dubai
[2]University of Wollongong in Dubai
[3]Aims Senegal
*assanlo@uowdubai.ac.ae

Keywords
Navier-Stokes equations, incompressible flow, irrotational flow, potential flow, global regularity.

Abstract

This paper addresses a specific class of solutions to the three-dimensional incompressible Navier-Stokes equations with conservative external forcing. We investigate flows where the initial velocity field is both divergence-free (incompressible) and irrotational (curl-free), corresponding to potential flow conditions. Using convolution methods combined with fundamental vector calculus identities, we construct smooth, globally regular solutions for this restricted class of initial conditions. We demonstrate that when the initial flow is Laplacian (both solenoidal and irrotational) and the external force is conservative, the Navier-Stokes system admits C^∞ solutions in $R^3 \times R^+$. Furthermore, we construct physically realizable flows with periodic behavior in two spatial directions and controlled decay in the third, avoiding singular behavior at infinity. We extend this analysis by introducing a decomposition framework that relaxes the curl-free constraint, employing vector potential methods to handle more general divergence-free initial conditions. While these solutions represent a special subset of possible fluid flows, they provide rigorous examples of global regularity and offer insights into the mathematical structure of the Navier-Stokes equations.

References

[1] Charles L. Fe¤erman: O¢ cial Problem Description - Charles Fefferman Clay Mathematics Institute
[2] JKeith J. Devlin, The Millennium Problems: The Seven Greatest Unsolved Mathematical Puzzles of Our Time, Basic Books (October, 2002), ISBN 0-465-01729-0.
[3] Peter D. Lax, Functional Analysis,Wiley-interscience(2002)
[4] Yaakov B. Natan, and Weit Y. Integrable Harmonic functions on R^n Jour.of.Funct.Analysis 150, 471-477 (1997).
[5] A. Bertozzi and A. Majda, Vorticity and Incompressible Flows, Cambridge U. Press, Cambridge, 2002.
[6] L. Ca¤arelli, R. Kohn, and L. Nirenberg, Partial regularity of suitable weak solutions of the Navier-Stokes equations, Comm. Pure & Appl. Math. 35 (1982), 771-831.
[7] P. Constantin, Some open problems and research directions in the mathematical study of fluid dynamics, in Mathematics Unlimited2001 and Beyond, Springer Verlag, Berlin, 2001, 353-360.
[8] O. Ladyzhenskaya, The Mathematical Theory of Viscous Incompressible Flows (2nd edition), Gordon and Breach, New York, 1969.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-28-O: Spectral Management in Hybrid Photovoltaic Thermal Systems: A Thermofluid Dynamics Approach

Mohit Barthwal[1,2], Dibakar Rakshit[1,2,*]
[1]Indian Institute of Technology Delhi Abu Dhabi, Abu Dhabi, United Arab Emirates
[2]Indian Institute of Technology Delhi, New Delhi, India
*dibakar@iitdabudhabi.ac.ae

Keywords
Opto-thermal analysis; photovoltaic thermal; thermo-fluid analysis; thermal management

Abstract

Photovoltaic-thermal (PVT) collectors maximize solar energy utilization by generating electricity and usable heat from the same entity. However, conventional PVT systems face spectral mismatch: high-energy photons cause excessive heating of photovoltaic (PV) components, leading to efficiency losses, while low-energy infrared (IR) photons are inefficiently converted to electricity and produce low-grade thermal output. Addressing this thermal-electrical coupling challenge is crucial for advancing hybrid solar technologies. This presentation outlines a study combining thermofluid modeling, nanofluid optics, and system-level techno-economics to tackle these limitations. It quantifies the annual electrical, thermal, and exergy outputs of an actively cooled PVT system across various climates and assesses feasibility for residential applications such as heating, cooling, and hot water when integrated with an absorption chiller. These results define the performance limits of conventional designs.

Building on these insights, we introduce spectral beam splitting (SBS) using oxide-based nanofluid optical filters to separate photovoltaic and photothermal conversion processes. A coupled optical thermal-electrical framework evaluates the hybrid collector's performance, demonstrating that redirecting IR photons to a thermal receiver reduces PV temperature, enhances electrical efficiency, and generates higher-quality heat. We detail the screening, synthesis, and characterization of oxide-based nanofluids, supported by a theoretical Rayleigh-scattering-based optical model to predict their transmittance and absorbance profiles. Finally, we fabricated and experimentally validated a scaled hybrid module combining a silicon PV cell with a custom nanofluid filter housed in 3D-printed and laser-cut enclosures. Laboratory tests confirm the effectiveness of SBS: PV cell operating temperatures are reduced, electrical conversion efficiency is improved, and redirected IR energy is successfully harvested as usable heat. This work illustrates a scalable pathway toward high-efficiency solar cogeneration, positioning SBS-enabled PVT systems as a compelling option for distributed energy networks and hybrid renewable configurations where both electricity and heat are valuable.

Oral Presentation	**X**
Poster Presentation	

STAM 2025-30-O: Novel Hierarchical Fractal Geometries for Gypsum Scaling Control in Membrane Distillation: Computational Fluid Dynamics Approach

Balsam Swaidan[1, 2*], Immanuvel Paul[1, 2]& Simon Ching Man Yu[1]
[1]Department of Aerospace Engineering, Khalifa University, P.O. Box 127788, Abu Dhabi, UAE
[2]Center for Membranes and Advanced Water Technology (CMAT), Khalifa University, Abu Dhabi, UAE
*Balsam.Swaidan@ku.ac.ae

Keywords
Fractal patterns; Gypsum scaling; Surface modification; Water treatment

Abstract

The formation of gypsum scale presents a major obstacle to the commercial adoption of membrane distillation (MD) technology. This research presents novel microscale fractal-inspired surface membrane designs for direct contact membrane distillation (DCMD), featuring hierarchical structural arrangements within unified length scales to improve anti-scaling properties. Through integrated computational fluid dynamics (CFD) analysis combined with population balance modeling for gypsum crystal formation, we conducted a comprehensive evaluation of fractal-patterned membranes using a 2×2 factorial experimental framework investigating membrane surface features (indentation vs. protrusion) at orientation (0° vs. 45° configurations). Indented fractal configurations showed 35-37% improvement in pure water flux compared to smooth membrane controls while preserving comparable pressure differentials. The 45° indented fractal design maintained excellent flux consistency during extended 16-hour scaling experiments. Performance benchmarking against conventional ridge-groove architectures highlighted critical design considerations: while ridge-groove patterns initially produced 10% higher flux, they experienced severe >90% flux deterioration compared to the sustained operation of fractal designs. Shear stress characterization reveals that fractal surface geometries create more homogeneous stress fields via hierarchical, multi-dimensional flow perturbation, successfully reducing stagnation regions where crystal formation is favored. These results contribute to advancing MD technology deployment in demanding water treatment applications through targeted fluid dynamic optimization.

Oral Presentation	**X**
Poster Presentation	

STAM 2025-31-O: Spectral Signatures and Inter-Scale Dynamics of Non-Kolmogorov Single-Bubble Turbulence

Majeed N.J.[1 *], Paul I.[1] & Yu S.C.M.[1]
[1]Khalifa University, Abu Dhabi
*100062551@ku.ac.ae

Keywords
Bubble Induced Turbulence (BIT), Energy Spectra, Anisotropic

Abstract

Single-bubble turbulence (SBT) is investigated through direct numerical simulations, focusing on its distinct spectral features and the mechanisms of energy transfer within a rising bubble's wake. Unlike classical homogeneous isotropic turbulence (HIT), bubble-induced turbulence (BIT) [1], or two-dimensional turbulence (2DT) [2], SBT displays a fundamentally different cascade behavior driven by buoyancy, capillarity, and anisotropic wake dynamics.

Using a coarse-graining framework, the study reveals scale-dependent energy and enstrophy fluxes and their directional characteristics. Two clear spectral regimes are identified: a k^-3 scaling at scales larger than the bubble diameter, and a steeper k^{−19/3} scaling at smaller scales. Energy is mainly injected at scales near the bubble diameter, while enstrophy injection occurs at smaller scales, indicating a decoupling between energy and enstrophy dynamics.

The energy cascade remains mostly forward, but inverse transfer appears in narrow angular sectors aligned with the bubble's rise. Enstrophy dynamics are non-canonical; vortex stretching does not fully balance flux and dissipation, and the injection scale shifts with bubble size. These findings show that SBT is governed by a unique, anisotropic cascade process modulated by surface tension, not captured by classical turbulence theory.

References

[1] Risso, Frédéric. "Agitation, Mixing, and Transfers Induced by Bubbles." *Annual Review of Fluid Mechanics*, vol. 50, no. 1, 2018, pp. 25–48. *Annual Reviews*, doi:10.1146/annurev-fluid-122316-045003.
[2] Kraichnan, Robert H. "Inertial Ranges in Two-Dimensional Turbulence." *The Physics of Fluids*, vol. 10, no. 7, 1967, pp. 1417–23.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-33-P: Nondestructive Evaluation of Artificial Bone Using Highly Nonlinear Solitary Waves

Mariam Barakat[1*], Tae-Yeon Kim[2], Andreas Schiffer[1]
[1]Department of Mechanical and Nuclear Engineering, Khalifa University of Science and Technology, Abu Dhabi, 127788, UAE
[2]Department of Civil and Environmental Engineering, Khalifa University of Science and Technology, Abu Dhabi, 127788, UAE
*100049826@ku.ac.ae

Keywords
Non-destructive testing; bone quality assessment; artificial bone.

Abstract

Highly nonlinear solitary waves (HNSWs) are compact, localized, non-dispersive waveforms that are highly sensitive to variations in contact stiffness, making them powerful for assessing material properties and detecting defects [1]. This study combines experimental and numerical investigations of HNSW interactions with 3D-printed bone microstructures for non-invasive site-specific bone quality assessment. Realistic bone models were generated from CT scan data using topology optimization, as described previously in the literature [2]. The digital models were 3D printed using micro-stereolithography and evaluated using an HNSW-based 1D granular crystal sensor. An incident solitary wave was generated in the chain by the impact of a striker bead and propagated through the chain to the last bead–bone interface. The interaction between the bone and the incident wave resulted in two distinct HNSWs whose amplitude and time delay were strongly correlated with the elastic moduli of the printed bone specimens. A discrete element model (DEM) was developed to simulate this interaction, yielding a good agreement between the predictions and measurements. The DEM predictions revealed that the delay in the formation of reflected HNSWs is significantly reduced with increasing sample radius and approaches a stationary value when the sample is much larger than the contact zone. Overall, the findings demonstrate the potential of HNSW-based testing with 3D-printed bone models as a novel, non-destructive method for quantifying bone mechanical properties and assessing localized bone quality.

References

[1] J. Yang et al., “Nondestructive evaluation of orthopaedic implant stability in THA using highly nonlinear solitary waves,” Smart Mater Struct, vol. 21, no. 1, Jan. 2012, doi: 10.
[2] I. G. Jang and I. Y. Kim, “Computational study of Wolff’s law with trabecular architecture in the human proximal femur using topology optimization,” J Biomech, vol. 41, no. 11, pp. 2353–2361, Aug. 2008, doi: 10.1016/j.jbiomech.2008.05.037.

Oral Presentation	
Poster Presentation	**X**

STAM 2025-34-O: Inherent Thermodynamic Performance Assessment of a Variable Refrigerant Flow System under Transient Cooling Load: A Case Study of an Eco-Villa

Muhammad Reshaeel, Mohamed I. Hassan Ali *
[1]Mechanical and Nuclear Engineering Department, College of Engineering and Physical Sciences,
[2]Khalifa University of Science and Technology, P.O.Box 127788, Abu Dhabi, United Arab Emirates
*100063022@ku.ac.ae

Keywords
Variable refrigerant flow system, Exergy analysis, Environmental impact, Statistical analysis

Abstract

Variable refrigerant flow (VRF) systems are among the most energy-efficient heating ventilation and air-conditioning technologies. However, their intrinsic thermodynamic behavior and the interdependencies among internal performance variables remain insufficiently understood. Therefore, this study develops a detailed MATLAB-based mathematical model of a VRF system installed in an eco-villa in Masdar City, Abu Dhabi, to evaluate its thermodynamic behavior and environmental impact under dynamic operating conditions. The model demonstrates strong predictive reliability, achieving a coefficient of determination of 0.89, a mean absolute error of 0.04 kW, and a mean square error of 0.01 kW^2. Energy and exergy analyses reveal that the system dynamically adjusts compressor speed in response to transient cooling loads, enhancing isentropic efficiency and part-load performance. This adaptive operation reduces compressor power consumption by 11.1% and increases the coefficient of performance (COP) by 12.5% under minimum load conditions compared to conventional constant-speed systems. Pearson correlation analysis confirms and complements the energy and exergy analysis statistically by showing that higher ambient temperatures significantly increase compressor speed, which raises power consumption and reduces overall efficiency during peak loads. Conversely, elevated evaporation temperatures exhibit a strong positive correlation with isentropic efficiency, thereby improving both COP and exergy efficiency, aligning with the system's enhanced part-load performance. In contrast, higher condensation temperatures display a negative correlation with efficiency, intensifying irreversibilities and exergy losses. The statistical analysis validates the dynamic coupling between energy consumption, thermodynamic efficiency, and system irreversibilities. Finally, the environmental evaluation demonstrates that adopting the VRF system results in a 15.38% reduction in annual energy consumption and a 1.51-ton annual decrease in CO_2 emissions per eco-villa—equivalent to 1,509.75 tons for 1,000 villas—underscoring the dual thermodynamic and environmental advantages of VRF systems and highlighting their potential as a sustainable and intelligent cooling solution for hot climates.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-35-O: Validation of Imbert-Fick Law using Finite Element Analysis and Experimental Testing of Artificial Cornea

Leo Puthussery Jose[1]*, Nader Vahdati[1], Marwan El-Rich[1] & Mohamed L Seghier[1]
[1]Khalifa University, AbuDhabi, UAE
*100062810@ku.ac.ae

Keywords
Imbert-Fick law, Intraocular Pressure, Glaucoma, Artificial Cornea, FEA

Abstract

Glaucoma is a major cause of irreversible blindness, and accurate measurement of intraocular pressure (IOP) is critical for its diagnosis and management. Most tonometers used in clinics are based on the Imbert–Fick law, which assumes that the external pressure needed to flatten the cornea equals the internal pressure inside the eye. However, this assumption often ignores the influence of corneal thickness and elasticity, leading to inaccurate IOP readings. In this work, the Imbert–Fick law was validated using Finite Element Analysis (FEA), while experimental testing was performed on a silicone-rubber artificial cornea whose Young's modulus (0.11 MPa) matched that of the human cornea[1]. The simulation results showed that when the corneal thickness is small, the pressure measured on the outer surface closely matches the actual internal pressure, confirming the Imbert–Fick relationship. However, as thickness increases, the outer pressure becomes much higher than the true internal pressure due to structural stiffness effects. For an artificial corneal thickness of 0.7 mm and an internal pressure of 11.25 mmHg, the Rebound Tonometer and TonoPen measured 30 mmHg and 36 mmHg respectively while the FEA-predicted pressure was 19.5 mmHg. These results indicate that corneal geometry strongly affects IOP

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-36-O: Multi-resolution DMD Analysis of Swirling Spray Dynamics under Flowrate and Ethanol Blending Effects

Ibrahim Alsafadi[1*], Afshin Goharzadeh[1] & Hamid Ait Abderrahmane[1]
[1]Department of Mechanical and Nuclear Engineering, Khalifa University, Abu Dhabi, UAE
*100061876@ku.ac.ae

Keywords
Atomization; SPIV; mrDMD; RPCA; Swirling Jet Dynamics

Abstract

Atomized jets play a vital role in numerous engineering systems, including fuel injection, spray cooling, agriculture, and additive manufacturing. However, their complex multiphase and multiscale dynamics remain poorly understood, and the absence of a unified theoretical framework limits predictive modeling of droplet breakup and spray behavior. Recent advances in data-driven flow analysis have shown promise in addressing this challenge [1]. Traditional modal decomposition techniques such as Proper Orthogonal Decomposition (POD) and Dynamic Mode Decomposition (DMD) often require time-resolved data, restricting their use for experimental studies with limited temporal resolution. The multi-resolution Dynamic Mode Decomposition (mrDMD) framework, however, offers a hierarchical frequency-based decomposition capable of extracting coherent modes even from non-time-resolved datasets [2,3]. When combined with preprocessing approaches such as Robust Principal Component Analysis (RPCA) for denoising [4], mrDMD provides a powerful means of revealing dominant dynamical features in turbulent and atomized flows.

In this study, Stereoscopic Particle Image Velocimetry (SPIV) was employed to investigate the internal flow characteristics of pressure-swirl atomizers operating with deionized water and ethanol–water mixtures of varying concentrations (E10, E20, and E50). Details on the SPIV and the experimental set up are provided in Alsafadi et al. [5] and Abdullah et al. [6] respectively. The instantaneous velocity fields were first processed using RPCA to separate coherent flow features from measurement noise, followed by mrDMD to extract the dominant spatiotemporal modes and oscillation frequencies of the spray. The analysis revealed a fundamental oscillation frequency that remained invariant across all tested flowrates and fluid compositions, indicating the presence of an intrinsic, self-sustained oscillatory mechanism governing the atomization process. These findings lay the groundwork for future data-driven identification of the underlying governing equations of atomized jet dynamics, bridging experimental observations with predictive, equation-based modeling frameworks [7].

References

[1] B. Begiashvili, N. Groun, J. Garicano-Mena, S. Le Clainche, E. Valero, Data-driven modal decomposition methods as feature detection techniques for flow problems: A critical assessment, arXiv preprint arXiv:2212.12416, (2022).
[2] J.N. Kutz, X. Fu, S.L. Brunton, Multi-resolution dynamic mode decomposition, SIAM Journal on Applied Dynamical Systems, 15, 713–735, (2016).
[3] D. Dylewsky, M. Tao, J.N. Kutz, Dynamic mode decomposition for multiscale nonlinear physics, arXiv preprint arXiv:1903.12480, (2019).
[4] I. Scherl et al. , Robust principal component analysis for modal decomposition of corrupt fluid flows, Phys. Rev. Fluids, 5, 054401, (2020).
[5] A. Alsafadi et al., Experimental study on spray dynamics using Stereoscopic Particle Image Velocimetry, Experimental Thermal and Fluid Science, (2025).

[6] M. Abdullah et al., Characterization of pressure-swirl atomizers under varying ethanol-water mixtures, International Journal of Multiphase Flow, (2025).
[7] S.L. Brunton, J.L. Proctor, J.N. Kutz, Discovering governing equations from data by sparse identification of nonlinear dynamical systems, Proceedings of the National Academy of Sciences, 113, 3932–3937, (2016).

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-37-O: Bio-Inspired V-Formations for Low-Speed Micro Aerial Vehicles

Abikrishnaa Parimelalagan[1*], Majid Hassan Khan[1]
[1]Department of Mechanical Engineering, Birla Institute of Technology and Science, Pilani, Dubai Campus, Dubai International Academic City, Dubai, United Arab Emirates
*abikrishnaa.p@gmail.com

Keywords
Bio-inspired formation, V formation aerodynamics, Micro aerial vehicles, Proper orthogonal decomposition

Abstract

Energy optimization for sustained flight has been an evolutionary trait of birds. Bio-inspired V formation during the flight of micro-aerial vehicles (MAVs) helps in passive flow control. The present work employs OpenFOAM-based simulations for V formation of fixed-wing micro-aerial vehicles modeled as equilateral triangle prisms. A V formation angle of 45 degrees with varying numbers of MAVs flying at a low Reynolds number of 100 has been used to examine the flight. The present work discusses the effect of the number of vehicles for a fixed V formation angle. Passive flow control and the influence of the bird configuration on wake, force coefficients, shedding frequencies, and coherent structures in the wake have been investigated. Insights into different modes of the coherent structures have been acquired using proper orthogonal decomposition.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-38-O: Enhancing Lightweight Universal Talus Implants: The Role of a Compliant Polycarbonate-Urethane Coating in Reducing Contact Pressures

Ahmed H. Hafez[1*], Mubinul Islam[1], Muhammad Mujtaba Syed[1], Tao Liu[2], Marwan El-Rich[1]
[1] Department of Mechanical and Nuclear Engineering, Khalifa University, Abu Dhabi, UAE
[2] Department of Mechanical and Manufacturing Engineering, Ontario Tech University, Oshawa, Canada
*100044977@ku.ac.ae

Keywords
Cartilage, Contact pressure, Finite element analysis, Optimized universal total talus replacement, Artificial coating

Abstract
Total talus replacements offer a promising solution for severe talus fractures complicated by avascular necrosis and collapse [1]. While topologically optimized universal talus implants provide advantages, such as reduced weight and lower costs compared to patient-specific designs, their stiff material composition raises concerns about long-term cartilage wear and bone fracture [2]. To address this, we propose integrating a compliant polycarbonate-urethane (PCU) coating onto the implant surface. Using finite element analysis (FEA), we evaluated the biomechanical effects of this modification across three postures in four subjects. Results demonstrated a 13.4-72.4% reduction in peak contact pressures on surrounding cartilage, alongside maintained structural integrity, with safety factors ranging from 4.1 to 8.6. Although further mechanical testing is needed, these simulations strongly suggest that a compliant PCU layer can significantly improve load distribution while preserving implant integrity. This innovation has the potential to enhance clinical outcomes by mitigating cartilage degeneration and fracture risks in total talus replacements.

References
[1] A. H. Hafez et al., “A Finite Element Study of the Universality and Scalability of an Optimized Universal Talus Implant,” p. 158–163, (2024)
[2] T. Liu et al., “Polycarbonate-urethane coating can significantly improve talus implant contact characteristics,” vol. 125, p. 104936, (2022)

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-39-O: TPMS Heat Exchangers for Enhanced Freshwater Production in Humid Environments

Omar Abdelqader[1,2], Rashid K. Abu Al Rub[1,2], Mohamed I. Hassan Ali[1,2,3]
[1]Mechanical & Nuclear Engineering Department, College of Engineering and Physical Sciences,Khalifa University, P.O. Box 127788, Abu Dhabi, UAE
[2]Advanced Digital & Additive Manufacturing (ADAM) Group, Khalifa University, P.O. Box127788, Abu Dhabi, UAE
[3]Center for Membrane and Advanced Water Technologies (CMAT), Khalifa University, P.O.Box 127788, Abu Dhabi, UAE
*100060584@ku.ac.ae

Keywords
Dehumidification, TPMS, Atmospheric air, Finned tube, Heat exchanger

Abstract

This study explores freshwater generation from atmospheric air using various tube configurations and orientations, including smooth, finned, and triply periodic minimal surface (TPMS) geometries—specifically Schoen's Gyroid and IWP. Through validated 3D computational fluid dynamics (CFD) simulations, the performance of these designs was compared under identical humidity and flow conditions to identify optimal surface characteristics for maximizing water vapor condensation. Results show that horizontally oriented tubes achieved higher condensation rates than vertical ones, attributed to their greater length-to-diameter ratio and favorable fin alignment. The horizontal annular finned tube enhanced the condensation rate by a factor of 2.3. Moreover, the Gyroid-Solid TPMS structure produced 40% more water than the annular finned tube, while the IWP-Solid structure achieved a 10% increase. At lower Reynolds numbers, Gyroid and IWP sheet designs yielded less condensate due to reduced flow momentum through TPMS pores; however, at higher Reynolds numbers, the Gyroid sheet exceeded the finned tube's performance by promoting enhanced turbulence, with the IWP sheet delivering similar results. Overall, this investigation highlights the promising potential of TPMS structures and emphasizes how geometry, flow dynamics, and orientation collectively influence the efficiency of atmospheric freshwater harvesting systems.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-40-O: Sustainable and Portable Kapok-Based Hydroelectric Generators with High Power Density for Wearable Applications

Dawei Zhang[1,3], Dezhuang Ji[1], Baosong Li[2,4], Xinyu Wang[5], Abdallah Kamal[1,4], Hongtao Zhang[1], Kin Liao[2,3,4], and Lianxi Zheng[1,3,4,*]
[1]Department of Mechanical and Nuclear Engineering, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates
[2]Department of Aerospace Engineering, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates
[3]Advanced Research and Innovation Center (ARIC), Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates
[4]Research & Innovation Center for Graphene and 2D Materials (RIC-2D), Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates
[5]Department of Biomedical Engineering, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates
*lianxi.zheng@ku.ac.ae

Keywords
Sustainable nanogenerator, nature fiber, hydroelectric, wearable devices, water evaporation.

Abstract

Natural fibers offer great opportunities for broad sustainable applications due to their unique microstructures and environmental abundance. In this study, we present the Raw-Kapok Cell Generator (RCG), a device that generates electricity through water evaporation based on the raw kapok fibers without the delignification treatment. Benefiting from its hydrophilic inner wall and hydrophobic outer shell, each kapok fiber can act as an individual power unit. By assembling these fibers in an aligned manner, the RCG can achieve an continuous output power density as high as 4.5 μW/cm² after optimizing the physical dimensions, fiber alignment, and packing density. It is also revealed that the continuous electrical output is driven by the contact electrification at water-fiber interface and water evaporation-induced charge migration, which in turn is strongly dependent on fiber microstructures and water transport. This work demonstrates the potential of kapok fibers for eco-friendly and reliable energy generation, representing a green solution of portable power sources for wearable devices.[1]

References

[1] D. Zhang, D. Ji, B. Li, X. Wang, A. Kamal, H. Zhang, K. Liao, L. Zheng, Sustainable and portable kapok-based hydroelectric generators with high power density for wearable applications, Sustain. Mater. Technol. 46 (2025) e01678.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-41-O: Low-Speed Impact Response and Shape Memory Effect of Surface-Based Nitinol Lattices

Mohamad Yassine[1*], Marwan El Rich[1], Wael Zaki[1]
Department of Mechanical and Nuclear Engineering, Khalifa University of Science and Technology, Abu Dhabi, 127788, United Arab Emirates
*100041730@ku.ac.ae

Keywords
Shape memory alloys; Thermally-induced shape recovery; Low-speed impact testing; TPMS structures; Penetration mechanics.

Abstract

Shape Memory Alloys (SMAs) are a class of metallic alloys demonstrating a remarkable ability to recover their original shape after deformation, typically through thermally induced phase transformations. This functional response is known as shape memory effect (SME), which is induced upon the reversible phase transformations within the material. Apart from SME, these alloys can also undergo relatively large deformations which can be partially or fully recovered upon unloading, unlike typical elastic materials. This property mostly associated with SMAs is known as super-elasticity. The class of metallic alloys derived from Nickel-Titanium (NiTi) compositions is certainly the most abundant family of SMAs, as they usually display notable super-elasticity and SME, along with other functional properties making them exceptional in various industries, including but not limited to biomedical, aerospace, and electrical engineering industries. Furthermore, advancements in additive manufacturing techniques have enabled the fabrication of complex triply periodic minimal surfaces (TPMS) geometries, potentially ideal for applications requiring lightweight yet structurally integral structures, superior energy absorption and impact resistance characteristics and remarkable mechanical properties.

The current study investigates the energy absorption properties and functional behavior of additively manufactured TPMS structures fabricated from NiTi (Nitinol). The TPMS samples investigated are fabricated from a nearly equiatomic composition of Nickel and Titanium powder, via the laser bed powder fusion (LBPF) additive manufacturing technique. The low-speed impact penetration response of the Nitinol TPMS samples is therefore investigated. The low-speed impact test utilizes the weighted drop impact system Instron CEAST-9350 equipped with a 20 mm diameter hemispherical impactor and a 90 kN load cell suitable for testing Nitinol structures. The test parameters including the impact energy, dropped mass, impact elevation and impact speed are kept constants for all tested samples for consistency. Subsequently, post-impact testing, the SMA samples are tested for their functional behavior and specifically their SME upon heating. By means of reverse engineering tools, namely coordinate measuring machines (CMMs), the shape recovery before and after the heating the samples is quantified, and the recovered depth, volume and radius of the imprint for the specimens are characterized. The latter will give insights into the healing potential of damaged Nitinol samples upon the thermally induced phase transformations. The study will present force-time plots, force-deformation curves, and results of shape recovery tests for each of the samples. In addition, the critical description and explanation of the general trends for the dynamic behavior of such structures under moderate strain rate loading, and the localized damage and failure phenomena occurring will be presented.

Oral Presentation	✔
Poster Presentation	

STAM 2025-43-O: Droplet Deposition into a Circular Hole with Sharp/Rounded Edge

Zhang Haokun[1*], Guan Qiangshun[1], MD Didarul Islam[1], Nader Vahdati[1], Firas Jarrar[2] & Yap Yit Fatt[1]
[1]Department of Mechanical and Nuclear Engineering, Khalifa University, Abu Dhabi, United Arab Emirates
[2]Department of Mechanical Engineering, Al Hussein Technical University, Amman, Jordan
*100057651@ku.ac.ae

Keywords
Droplet deposition, Hole, Sharp edge, Rounded edge, Deposition performance

Abstract

Precise placement of molten droplets into holes is essential for advanced manufacturing applications, yet this area remains largely unexplored. This study provides the first comprehensive numerical investigation of droplet deposition into circular holes with sharp and rounded edges. The confined hole geometry creates distinct pressure patterns, altered spreading behavior, and enhanced heat transfer compared to open surfaces. These effects lead to unique solidification patterns characterized by curved solidification fronts and narrowing flow channels within the hole. Systematic analysis of key parameters reveals that impact velocity has the greatest influence on deposition performance, followed by substrate temperature and droplet temperature. Using optimization methods, we identified an optimal parameter combination that increases the filled volume ratio by 33 % compared to standard condition. This optimized approach also improves performance for holes with rounded edges, achieving better material integration and fewer defects [1].

References

[1] Z. Haokun, G. Qiangshun, M.D. Islam, N. Vahdati, F. Jarrar, Ys.Y. Fatt, Droplet deposition into a circular hole with sharp/rounded edge, Int. Commun. Heat Mass Transf. 167 (2025) 109317.

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-44-O: Reliable Production of Small-Scale Microfluidic Features with SLA: Dimensional and Mechanical Insights

Ayah Al Babouli[1], Majid Malboubi[1*]
[1]University of Birmingham Dubai
[*] m.malboubi@bham.ac.uk

Keywords
Microfluidics, Microstructures, 3D Printing, Stereolithography (SLA), Print Orientation

Abstract

Applications of microfluidic devices have expanded significantly from natural and life sciences into fields such as water purification, environmental pollution monitoring, heavy metal removal, and plasma separation from blood. Over the last decade, the adoption of microtechnology has enabled experimentation at smaller scales, reducing costs and accelerating development timelines [1, 2]. The rise of 3D printing is revolutionizing manufacturing and production processes, including the fabrication of microfluidic devices. This additive manufacturing enables rapid prototyping, customization, and scalable production without the need for costly tooling. However, fabricating microfluidic devices with fine feature sizes still presents challenges such as achieving high resolution, smooth surface finishes, reliable bonding, and maintaining optical transparency. This study employs Stereolithography Apparatus (SLA) technology, which constructs objects layer by layer by curing liquid resin with a UV laser. We demonstrate successful fabrication of features as small as 80 micrometers, though reliability and repeatability become challenging below 200 micrometers. We investigate dimensional accuracy in microfluidic channels and protrusions printed in different orientations, varied geometries, and post-processing protocols. Quantitative microscopy reveals print orientation strongly impacts resin residue and dimensional fidelity. A critical spacing threshold of 300 µm was identified for protrusions to avoid resin accumulation. These results offer orientation- and geometry-dependent guidelines for reproducible fabrication of small-scale microfluidic structures, supporting consistent device manufacturing with affordable 3D printing.

References

[1] Gharib G, Bütün İ, Muganlı Z, Kozalak G, Namlı İ, Sarraf SS, et al. Biomedical Applications of Microfluidic Devices: A Review. Biosensors. 12(11):1023 (2022)

[2] Nie C, Shaw I, Chen C. Application of microfluidic technology based on surface-enhanced Raman scattering in cancer biomarker detection: A review. Journal of Pharmaceutical Analysis. 1;13(12):1429–51 (2023).

Oral Presentation	**selected**
Poster Presentation	

STAM 2025-45-P: Relationship between Reynolds Number and Flow-Induced Vibrations in Pipelines

Mohamed Alfazari, Mohammed Almahri, Abdulrahman Al Ali, Mohamed Fawzy*
Department of Petroleum Engineering, Abu Dhabi Polytechnic, UAE
*M00002695@actvet.gov.ae

Keywords
Flow-induced vibration, artificial intelligence, Reynolds number

Abstract

This study aims to investigate the relationship between flow-induced vibration behavior and fluid properties such as density, viscosity, temperature, and Reynolds number variations in pipeline systems. The objective is to understand how these parameters affect vibration amplitude and frequency under varying flow conditions. To achieve this, the work is structured into three main methodological stages. First, experimental measurements will be performed on a pipeline loop equipped with a pump, flow-rate indicator, pressure and temperature transmitters, and accelerometers to capture vibration signals and identify dominant frequency and amplitude characteristics. Second, theoretical modeling will be conducted using dimensional analysis and vibration mechanics to establish non-dimensional parameters linking fluid flow properties, including Reynolds number, to dynamic pipe response. Third, artificial intelligence tools will be applied to correlate measured and theoretical data, enabling pattern recognition and prediction of vibration behavior under different operating conditions. The study will conclude by integrating the experimental measurements and theoretical modeling to develop a comprehensive model for predicting flow-induced vibrations, serving as a foundation for future optimization and control strategies in industrial piping systems.

References

[1] G. Dinardo, L. Fabbiano, G. Vacca, and A. Lay-Ekuakille, Vibrational signal processing for characterization of fluid flows in pipes, Measurement, vol. 113, pp. 196–204, 2018.

Oral Presentation	
Poster Presentation	**selected**

STAM 2025-46-P: Modelling and Simulation of Cryogenic Liquid CO2 Pipeline Transportation Systems for Arid Environments

Mohamed Fawzy[1], Meera Alkhyeli[1], Hessa Almarri[1], Salama Alhajri[1], Meera Alzaabi[1]
[1]Abu Dhabi Polytechnic, Abu Dhabi, UAE
M00007956@actvet.gov.ae

Keywords
Cryogenic CO_2 transport, pipeline modeling, process optimization, cost estimation, arid environment, CCUS, UAE Net Zero 2050

Abstract

This study develops an integrated modeling, process design, and cost evaluation framework for transporting cryogenic liquid CO_2 through pipelines under hot and arid environmental conditions typical of the UAE. The study supports the UAE's Net Zero 2050 goals by enabling efficient carbon transport between capture and utilization facilities.

A steady-state model was developed to simulate the coupled hydraulic and thermal behavior of cryogenic liquid CO_2 during pipeline transportation. It accounted for conductive, convective, and radiative heat transfer to evaluate axial variations in temperature and pressure. This is necessary for estimating the maximum allowable transportation distance before interstage compression and refrigeration units. Techno-economic analysis took place for a hypothetical liquefaction process. This process included cascade refrigeration and the simulated pipeline system in addition to interstage refrigeration and boosting units. Optimization studies were conducted based on the minimum specific cost by varying key operating conditions, pipe insulation materials and geometric parameters.

Results revealed that inlet temperature, pressure, and insulation thickness are critical parameters controlling phase stability and maximum allowable pipeline length between interstage units. Among the materials evaluated, aerogel insulation achieved the lowest heat gain, extending the liquid-phase range, though with a higher material cost. Smaller diameters and elevated ambient temperatures shortened the stable region, while higher mass flow rates reduced thermal rise but increased frictional losses, indicating the presence of an optimal flow rate that balances energy efficiency and operational stability.

References

[1] M. Vitali, F. Corvaro, B. Marchetti, A. Terenzi, CO_2 transport by pipelines: Design criteria for safe and efficient cryogenic operation, *Energy Reports*, 7, 6358–6370, (2021).
[2] X. Lu, Y. Chen, Y. Wang, Q. Li, Simulation-based optimization of CO_2 pipeline transport with phase change considerations, *Energy Conversion and Management*, 226, 113518, (2020).
[3] X. Wang, Z. Zhang, Z. Liang, Energy optimization and cost assessment for CO_2 pipeline networks under different transport states, *Applied Energy*, 255, 113820, (2019).

Oral Presentation	
Poster Presentation	X

STAM 2025-47-O: Structural and Surface Modifications of Cesium Implanted SiC During Annealing in Vacuum and Helium Environments

H.A.A. Abdelbagi[1], J.B. Malherbe[2], A.S. El-Said[3], T.T. Hlatshwayo[2], S.S Ntshangase[1]
[1]Physics Department, University of Zululand, KwaDlangezwa, 3886, South Africa
[2]Physics Department, University of Pretoria, Pretoria, 0002, South Africa
[3]Physics Department and Interdisciplinary Research Center for Advanced Materials, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia
*Email: AbdelbagiH@unizulu.ac.za

Keywords
SiC, Whiskers growth, Fusion reactors

Abstract

Silicon carbide (SiC) is a promising candidate for first-wall materials in fusion reactors due to its excellent high-temperature stability and radiation resistance. However, helium (He) generated during fusion reactions can interact with reactor wall materials, potentially compromising their structural integrity. In this study, SiC wafers implanted with 300 keV Cs ions to a fluence of 2×10^{16} cm^{-2} at 600 °C were used to simulate defective SiC structures representative of reactor wall conditions. The as-implanted samples were sequentially annealed in two different atmospheres—vacuum and helium—between 800 °C and 1000 °C in steps of 100 °C for 1 hour. Annealing in vacuum resulted in smoother SiC surfaces, whereas annealing in helium led to the formation of surface whiskers, with their growth becoming more pronounced at higher temperatures ≥ 900°C. Furthermore, annealing at 900 °C and 1000 °C in a helium atmosphere induced surface oxidation, forming a thin SiO_2 layer. These findings reveal that prolonged exposure to helium at elevated temperatures can significantly degrade SiC surface integrity, raising critical concerns regarding its long-term suitability as a first-wall material in fusion reactors.

Oral Presentation	**X**
Poster Presentation	

STAM 2025-48-O: Deformation Analysis of a Coated Aircraft Wing using Fluid-Structure Interface

Husnain Raza Qasim[1*], Walid Abou-Hweij[1]
[1] Emirates Aviation University, Dubai, UAE
*10278982@eau.ac.ae

Keywords
Aircraft Wing; Surface coating; Fluid-structure interface; Aero elastic Deformation

Abstract

Lightweight materials are increasingly employed in aircraft design and structures due to their efficiency, as engineers strive to minimize aeroelastic deformations while reducing overall weight and production costs. This research aims to examine the effect of surface coatings—as an alternative to lightweight materials—on the deformation behavior of a NACA 64(2)215 aircraft wing using a fluid–structure interaction (FSI) model developed in ANSYS Workbench 2020 R1. The structural response of both coated and uncoated wings was analyzed using the finite element method (FEM), while the airflow dynamics were modeled through the finite volume method (FVM). Three coating materials—Titanium Nitride (TiN), Tantalum Carbide (TaC), and Chromium Nitride (CrN)—were investigated at varying thicknesses. The numerical results, validated with a grid convergence index (GCI) of 0.62%, demonstrated strong reliability. The findings indicated that the application of coatings substantially improved the wing's stiffness and reduced aerodynamic deformation. Specifically, a 5 mm TaC coating decreased the tip deflection of an aluminum wing by approximately 68% compared to the uncoated configuration. However, beyond an 8 mm coating thickness, additional benefits became marginal, identifying an optimal range between 4 and 8 mm. Overall, the study concludes that thin, high-modulus coatings can significantly enhance the stiffness and aeroelastic stability of metallic wings with minimal weight increase, presenting a promising strategy for strengthening future aircraft designs.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT in order to enhance the readability and language of the abstract. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content presented.

Oral Presentation	✔

STAM 2025-49-O: Numerical Investigation of Flow Dynamics Around a Heated Square Cylinder in Mixed Convection

Mohd Perwez Ali[1], Nadeem Hasan[2] & Sanjeev Sanghi[1*]
[1]Department of Applied Mechanics, Indian Institute of Technology-Delhi, Hauz Khas 110016, New Delhi, India
[2]Department of Mechanical Engineering, Aligarh Muslim University, Aligarh 202002, Uttar Pradesh, India
*sanghi@iitdabudhabi.ac.ae

Keywords
vortex instability, wakes, mixed convection, transition flow, buoyancy

Abstract

The flow dynamics around a heated square cylinder in mixed convection hold immense fascination for both engineers and fluid dynamicists. In this study, we employ direct numerical simulation (DNS) to investigate the three-dimensional flow transition in the wake of an infinite heated square cylinder subjected to horizontal free-stream cross-flow using air as the working fluid (Prandtl number Pr = 0.7). To maintain spanwise length constraints, we impose a periodic boundary condition, effectively limiting it to a finite length of Hz = 6D, where D signifies the side length of the square cylinder. Our approach utilizes an in-house non-Oberbeck–Boussinesq (NOB) model, which incorporates compressible gas flow equations to capture large-scale heating effects. To mitigate any potential impacts of pressure compressibility, all numerical results are meticulously computed at a low Mach number (Ma = 0.1). We observe significant changes in wake structure of streamwise vorticity over time at a Reynolds number of 250, across various heating levels, as defined by the over-heat ratio $\varepsilon = \beta\Delta T$, where β represents the thermal expansion coefficient, and ΔT signifies the temperature difference between the cylinder surface and the free-stream. As heating levels increase, we comprehensively examine the hydrodynamics and heat transfer characteristics.

Oral Presentation	yes
Poster Presentation	

9 Contact Us

For inquiries and to obtain further information,
please visit the website (https://ku.events/thermo-fluid-3/)

For other inquires or feedback, please email us at either hamid.abderrahmane@ku.ac.ae, afshin.goharzadeh@ku.ac.ae or yap.fatt@ku.ac.ae.