National Science Foundation – Directorate for Engineering

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Funding opportunities in multiphase flow

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Chemical, Bioengineering, Environmental, and Transport Systems Division
Directorate for Engineering

National Science Foundation – Directorate for Engineering

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Funding opportunities in multiphase flow

Transport Phenomena Cluster

- Fluid Dynamics
- Particulate and Multiphase Processes
- Combustion and Fire Systems
- Thermal Transport Processes

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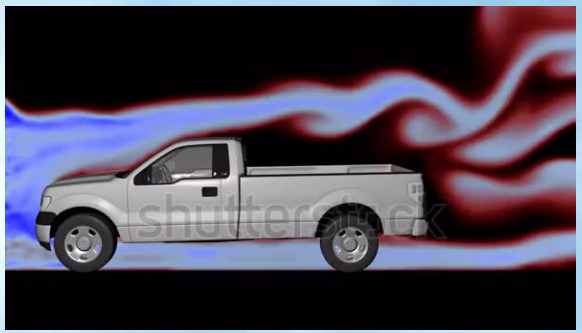
Fluid Dynamics

Fundamental research on the physics of various fluid dynamics phenomena using experiments, theory, and computation.

Transition & Turbulence



Bio-Inspired Flows

Interfacial Interactions and Instabilities

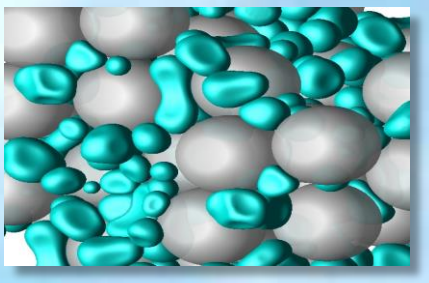
Micro- and Nano-fluidics

Complex Fluids

Particulate and Multiphase Processes

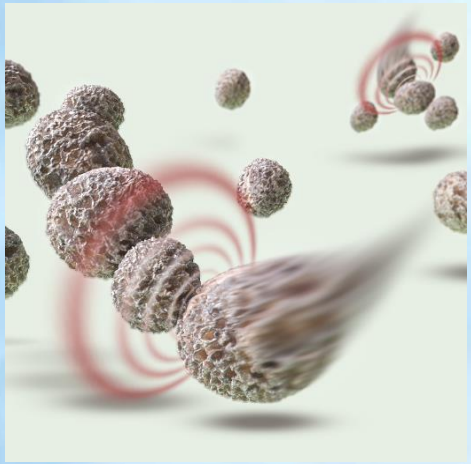
Fundamental research on physicochemical phenomena of particulate and multiphase systems - suspensions, emulsions, granular flows, micro- and nanostructured fluids, and self-assembly/directed-assembly processes

Emulsions

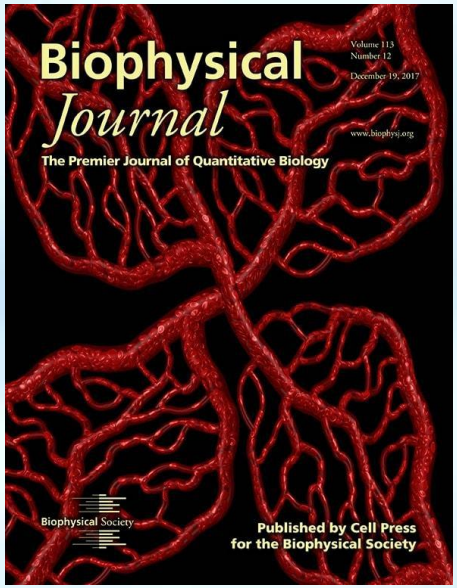


Granular flows

Suspension rheology



Physiological flows



Combustion and Fire Systems

Fundamental research on useful combustion-driven applications and on mitigating emissions and effects of fire.

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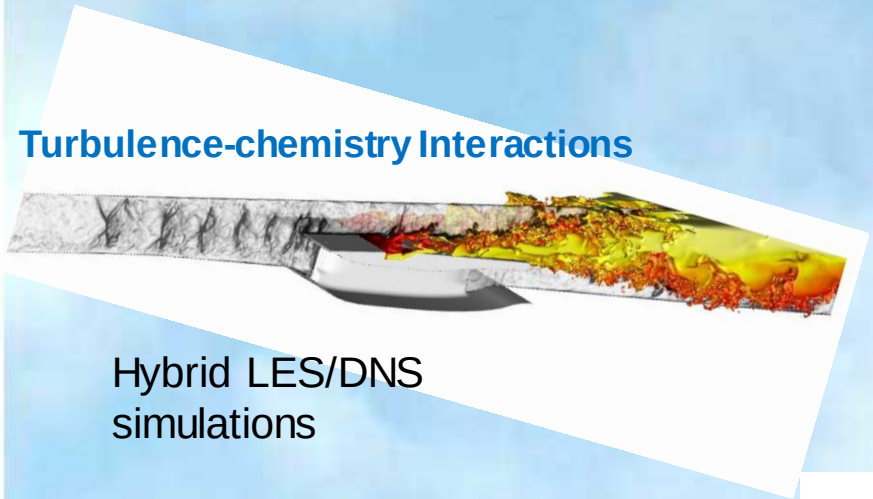
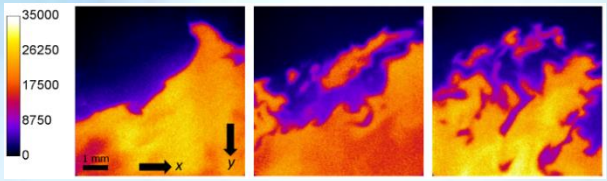
Turbulence-chemistry Interactions



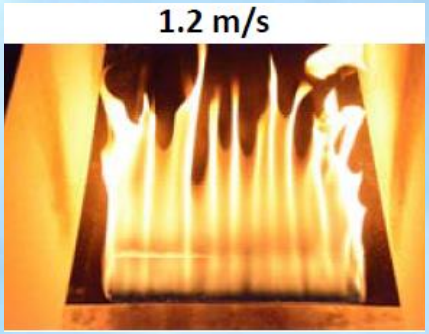
Hybrid LES/DNS simulations

In-situ diagnostics

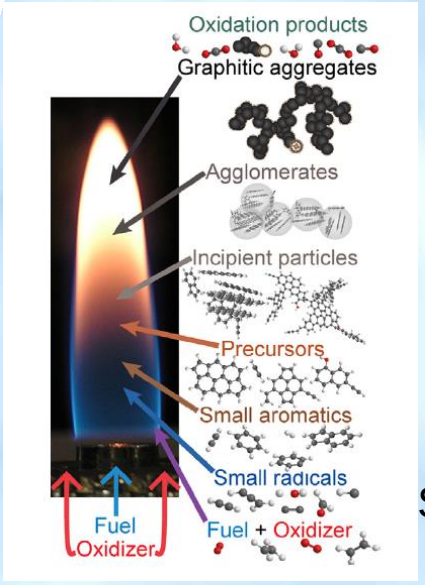


OH PLIF with 25x25x40 μm

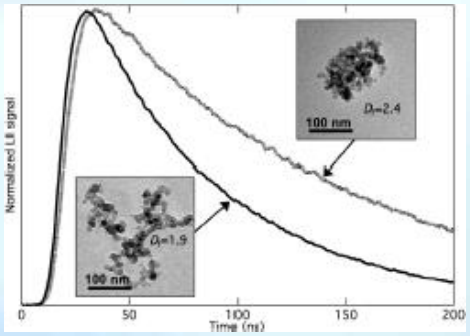
Fire dynamics



Effect of swirling flows



Combustion generated emissions and control



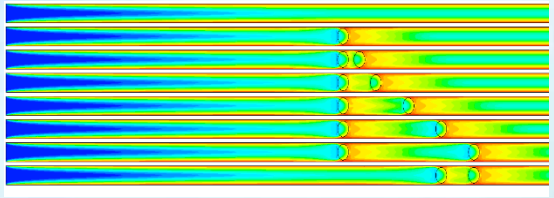
Soot nucleation and growth

Thermal Transport Processes

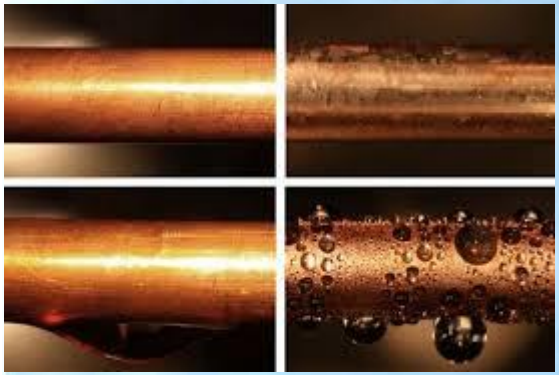
Fundamental research in thermodynamics and heat and mass transfer that combine analytical, experimental and numerical efforts geared toward understanding, modeling and predicting thermal phenomena

Energy Storage & Transmission

Convection Heat Transfer

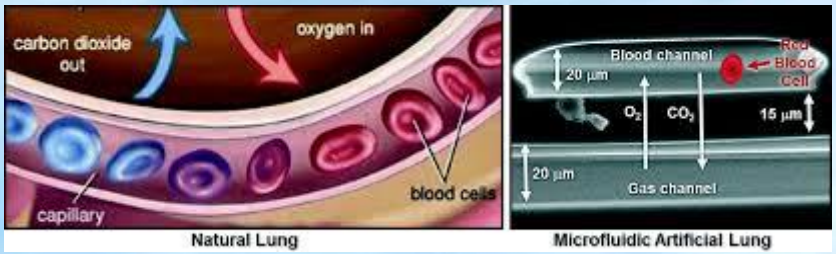


Phase Change



Solar Energy

Bio-heat/mass transfer



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2019 NSF Fluid Dynamics

Turbulence and Transition: theory; high Reynolds number experiments; large eddy simulation; direct numerical simulation; transition to turbulence; 3-D boundary layers; multi-phase turbulent flows; flow control and drag reduction.

Bio-inspired Fluid Mechanics: bio-mimetics; intracellular flows; fluid-structure interactions; hemodynamics; swimmers; insect flight; fins; biological flow processes; flows in biomedical devices; and drug delivery.

Flow of Complex Fluids: non-Newtonian fluid mechanics; flow of polymer solutions and melts; DNA dynamics; and new fluid materials.

Micro- and Nano-fluidics: micro-and nano-scale flow phenomena; biomedical microdevices; molecular dynamics simulations; and optofluidics.

Interfacial Interactions and Instabilities: hydrodynamic stability; gas-liquid interfaces; splashing; jetting; droplet interactions; atomization; and wetting.

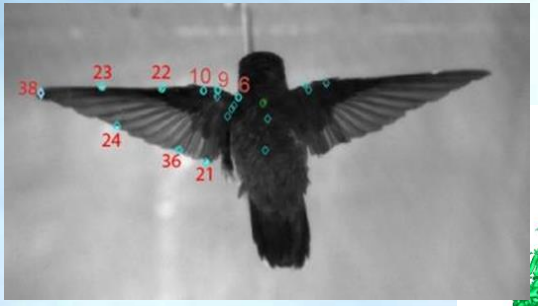
Instrumentation and Flow Diagnostics: Instrument development; MEMS; shear stress sensors; novel flow imaging; and velocimetry.

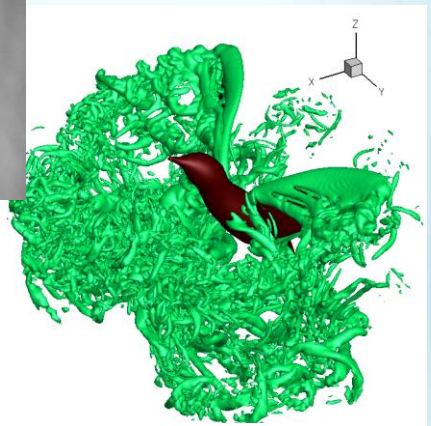
Fluid Dynamics Highlight

Computational Modeling of Wings in Nature

Haoxiang Luo, Vanderbilt U

Objective: Understand contribution of active and passive mechanisms to changes in wing shape and function within wingbeats.



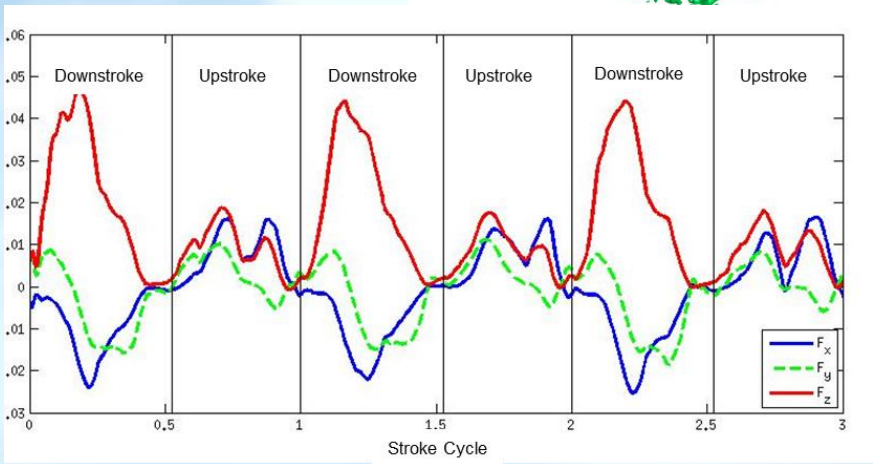


Experiments/Computations:

- Marker labels on the wing
- High-speed videos at 1000 fps (~25 f/c)
- Data extraction using a Matlab software
- Reconstruction of the kinematics (FEA/CFD)

Results:

- Total lift is close to weight
- Average lift produced during down-stroke is almost 2.6 times that of upstroke.



2019 Particulate and Multiphase Processes

Multiphase Flow Phenomena: dynamics of particle/bubble/droplet systems, rheology of multiphase systems, structured fluids, relating microscale phenomena to macroscale properties and process variables.

Particle science and technology: aerosols, particles and particle-polymer complexes with engineered properties, self- and directed assembly, template-directed assembly

Multiphase Transport in Biological Systems: analysis of physiological processes, applications of functionalized nanostructures in clinical diagnostics and therapeutics.

Interfacial Transport: dynamics of particles and macromolecules at interfaces, kinetics of adsorption and desorption from interfaces, complex molecular interactions at interfaces, formation of interfacial complexes and affect the dynamics of particles

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Unsolicited proposals to Engineering programs can be submitted at any time.

Recent awards in multiphase flow

CAREER: Towards Understanding and Modeling Turbulent Reacting Particle-Laden Flows; Jesse Capecelatro (Michigan)

Turbulent multiphase flow with interfacial mass and heat transfer: linking microscopic physics to macroscopic mixing; Rui Ni (Johns Hopkins)

Multi-scale modeling of multiphase flows and fluid-structure interactions in the lung; Donald Gaver (Tulane)

CAREER: Bubble fragmentation in turbulent flows; Luc Deike (Princeton)

Collaborative Research: Intermittency in Multi-Phase Flows in 2D and 3D Porous Media: Coordinated Experiments and Simulations; Farzan Kazemifar (Notre Dame)

Collaborative Research: A fundamental study on supercooled large droplets: impacting, splashing, surface water dynamics, and ice accretion; Hui Hu (Iowa State)

Center for the advancement of science in space (CASIS)

CASIS is the sole manager of the International Space Station U.S. National Laboratory.

NSF-CASIS collaboration … to benefit life on Earth

On Station

News and Views from the International Space Station U.S. National Laboratory.

PUBLISHED ON MONDAY, DECEMBER 14, 2015

CASIS and the National Science Foundation Announce Joint Solicitation in Fluid Dynamics

on the International Space Station

Kennedy Space Center, FL. (December 14, 2015) – The Center for the Advancement of Science in Space (CASIS) and the National Science Foundation (NSF) today announced a joint solicitation wherein researchers from the fluid dynamics community will have the ability to leverage resources onboard the International Space Station (ISS) U.S. National Laboratory. Up to $1.8 million will be awarded for multiple research investigations to support flight projects to the ISS National Laboratory.

CASIS | ISS U.S. NATIONAL LABORATORY

NSF 16-518
Fluid Dynamics

NSF 17-517
Combustion & Thermal Transport

NSF 18-521
Fluid Dynamics & Particulate/ Multiphase

NSF 19-525
Transport Phenomena Research

NSF 20-???
TBA

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Unmasking Contact-Line Mobility for Inertial Spreading using Drop Vibration and Coalescence

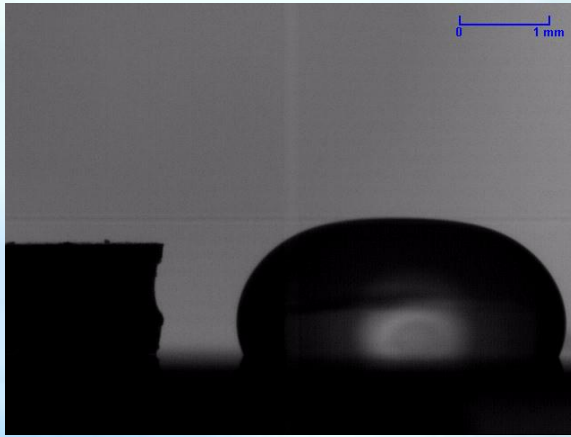
Paul Steen & Susan Daniel, Cornell University

Inertial spreading is the high-speed flow of a liquid across a surface. Predictions are difficult because of the presence of an advancing or receding line of contact between liquid, solid and surrounding gas.

Objective: Investigate fundamental aspects of the phenomenon and develop a theory to predict drop oscillation modes and the mobilization of droplets.

- Contact-line mobility measurement on Earth is challenging because of sticking and slipping that occurs at small scales and it happens fast.
- *The reduced gravity of the International Space Station (ISS) makes the corresponding behavior larger and slower and therefore possible to measure.*

A vibrating droplet is driven at resonance. Note the considerable motion of the contact-line on Earth.



NSF/AFOSR Partnership

2019 NSF Fluid Dynamics Program Description
NSF 18-1443

Fluid-Structure Interactions: NSF-AFOSR (Air Force Office of Scientific Research) joint funding focused on theory, modeling and/or experiments for hypersonics applications. Jointly reviewed by NSF and AFOSR using the NSF panel format. The AFOSR program that participates in this initiative is the Program on High Speed Aerodynamics (Program Officer: Dr. Ivett Leyva).

Computational and Data-Enabled Science and Engineering

Promote creation, development, and utilization of the next generation of theories, algorithms, methods, tools, and cyberinfrastructure in science and engineering applications.

High performance and emerging computational tools for mathematical modeling, simulation and analysis to analyze with greater fidelity, complexity and scale, engineering processes in chemical, biochemical and biotechnology systems, bioengineering and living systems, sustainable energy and environmental systems, and transport and thermal-fluids systems.

CBET Contact: Christy Payne (cpayne@nsf.gov)

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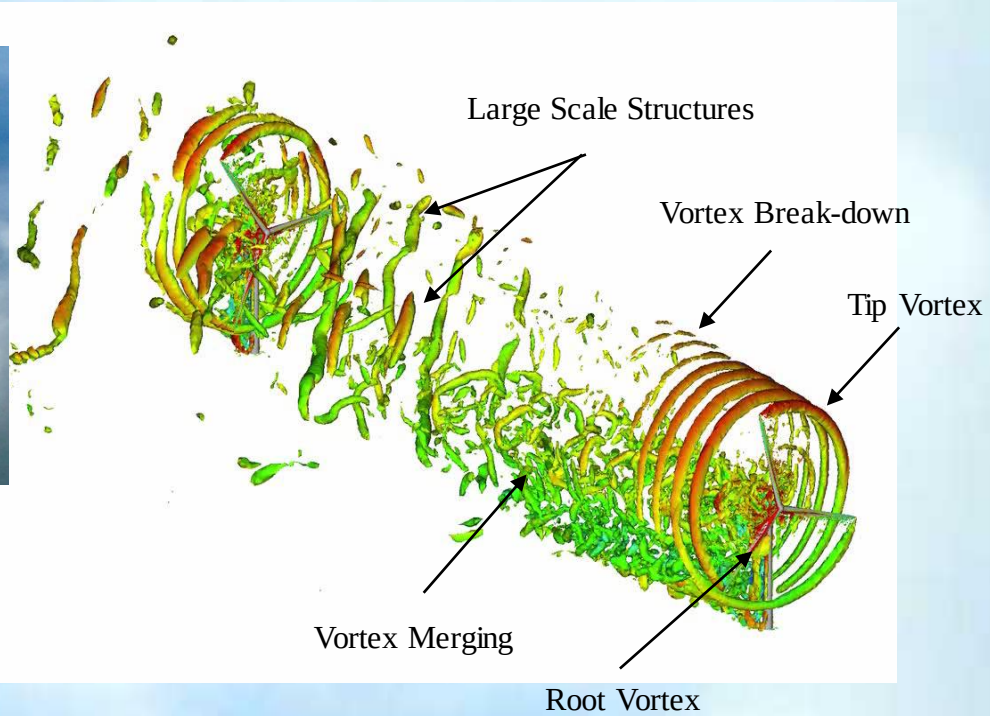
CDS&E Highlight

Unsteady Flow in Different Atmospheric Boundary Layer Regimes and Its Impact on Wind-Turbine Performance

Sutanu Sarkar, Scott Baden, Yuri Bazilevs, UC San Diego

Objective: Develop a novel data discovery framework using flash-based SSD to flexibly extract and interrogate space-time structures from large scale simulations – many Terabytes.

wind wakes take shape in the turbulence induced clouds behind the Horns Rev offshore wind farm west of Denmark. Image: NOAA



Major Research Instrumentation

Acquisition or **development** of major equipment to improve research/education quality and capability

- $100,000 to $4M with 30% cost share
- Non-PhD granting institutions: $0 to $4M; no cost share required
- Single, well-integrated instrument (not an ensemble of equipment)
- Shared used – multiple PIs
- Enable transformative research/education ← key
- Instrument management plan – must be "sustainable"

CBET Contact: Harsha Chellia (hchellia@nsf.gov)

NSF/UK Partnership

The **Engineering and Physical Sciences Research Council (EPSRC)** is the main funding body for engineering and physical sciences research in the UK. By investing in research and postgraduate training, we are building the knowledge and skills base needed to address the scientific and technological challenges facing the nation.

Our portfolio covers a vast range of fields from healthcare technologies to structural engineering, manufacturing to mathematics, advanced materials to chemistry. The research we fund has impact across all sectors. It provides a platform for future UK prosperity by contributing to a healthy, connected, resilient, productive nation.

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Coming later this month

EFRI: Distributed Chemical Manufacturing

National Science Foundation – Directorate for Engineering

Workshop: Machine Learning and Transport Phenomena

February 10-11, 2020
SMU Campus
Dallas, TX

National Science Foundation – Directorate for Engineering

NSF/EPSRC Fluid Dynamics Highlight

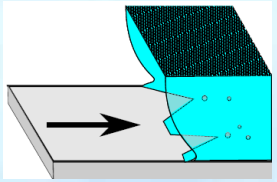
Dynamic Wetting & Interfacial Transitions in Three-Dimensions: Theory & Experiment

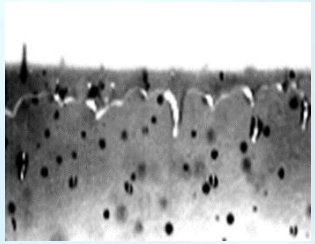
Satish Kumar, U of Minnesota-Twin Cities
Duncan Lockerby, James Sprittles (Warwick, UK); Alfonso Castrejón-Pita (Oxford, UK)

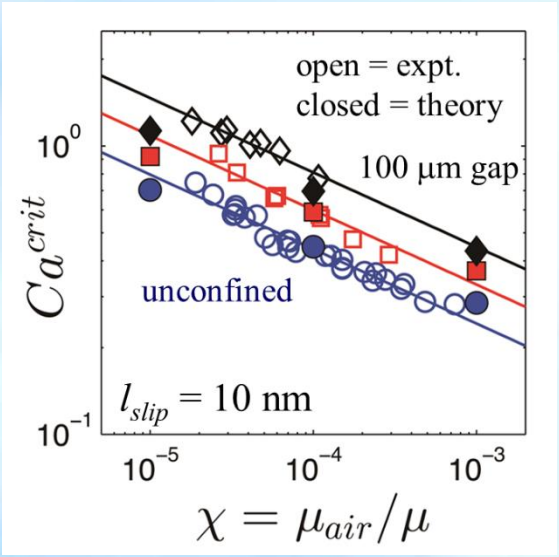
Objective: Analyze 3D interfacial instabilities (no theory exists) to create knowledge and a design-by-simulation capability for industrial processes – initial focus on the application of liquid-applied coatings.

Experiments/Computations:

- Flow visualization of contact line when subject to imposed perturbations of given wavelengths
- Analyze stability of 2D flows to 3D perturbations to predict wavelengths seen in experiments and to understand physical mechanisms
- Numerical simulations of 3D unsteady contact-line dynamics







Preliminary Results:

- Visualization of 3D structure of contact line at onset of wetting failure (2D to 3D transition due to natural perturbations)
- Accurate predictions of the critical speed at which the flow transitions from 2D to 3D

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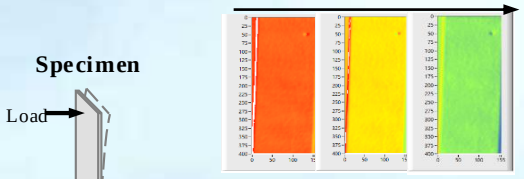
Fluid Dynamics Highlight

Luminescence-Based Pressure and Strain Measurement for High-Speed Fluid Structure Interactions

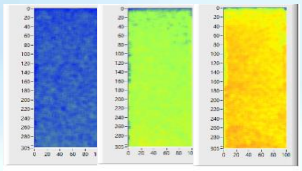
J. Paul Hubner, U of Alabama Tuscaloosa

Objective: integrate two luminescent-based optical sensors to study fluid structure interactions (FSI) in supersonic and (eventually) hypersonic flows.

Super-pixel Average decreasing pressure



Super-pixel St Dev; increasing strain



Experiments:

- Year 1: Couple pressure sensitive paint (PSP) and luminescent photoelastic coating (LPC); instrumentation and benchtop tests
- Year 2: Measure unsteady, distributed pressure and strain on a deformable surface at Mach~3.
- Year 3: Demonstrate at outside aero-facility on a panel/surface at higher Mach number

Results:

- Purchased and installed micro-polarizer camera and high-powered LED lamp
- Developed dual-coating application procedure
- Developed LabVIEW/Matlab analysis codes
- Tested cantilever calibration specimens under static load; dynamic tests started in August

Benchtop test apparatus