UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

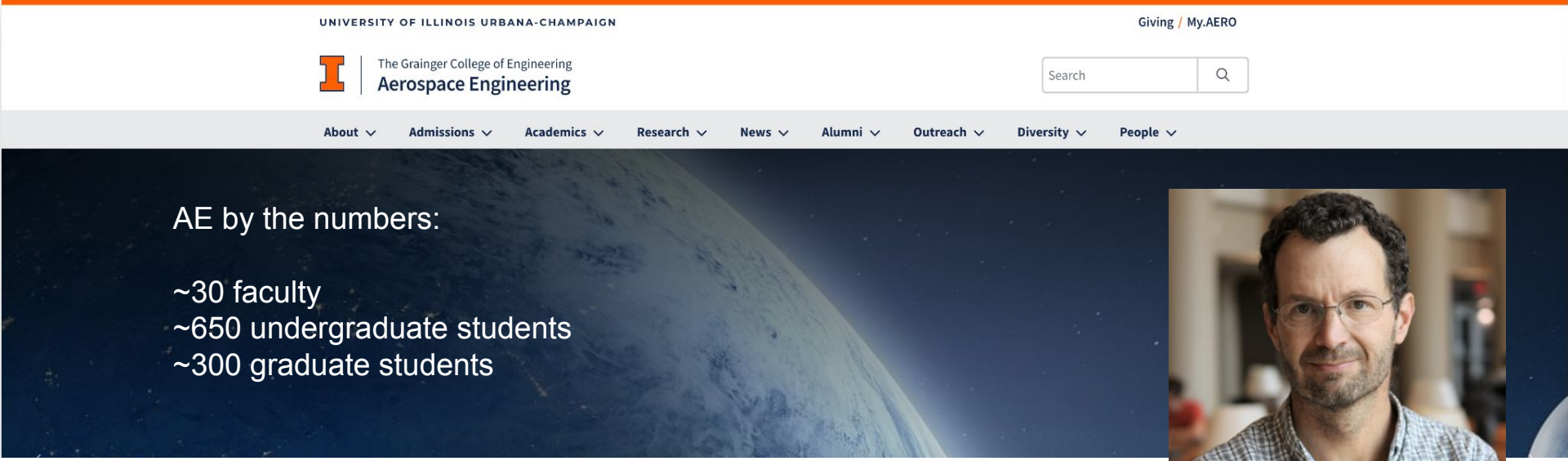
Department of Aerospace Engineering

Astrofest 2023

Siegfried Eggl

April 28, 2023

Department of Aerospace Engineering / Grainger College of Engineering



AE by the numbers:

~30 faculty
~650 undergraduate students
~300 graduate students

Research Domains:

- Aerodynamics, Fluid Mechanics, Combustion and Propulsion
- Controls and Dynamical Systems
- Space Systems
- Structural Mechanics and Materials

Department Head: Jon Freund

Examples of Centers with substantial AE involvement

- Center for UAS Propulsion (CUP)
- Center for Sustainable Aviation
- Center for Cryogenic High-Efficiency Electrical Technologies for Aircraft (CHEETA)
- Center for Exascale-enabled Scramjet Design
- Center for AstroPhysical Surveys (CAPS)
- IAU Centre for the Protection of the Dark and Quiet Skies (CPS)

Saxton-Fox receives College Award for Leadership or Institutional Impact on Diversity, Equity, and Inclusion

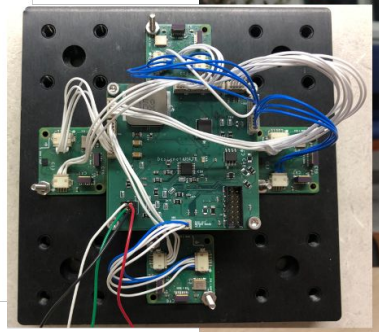
Diversity, Equity and Inclusion

- Aero's Space to Belong
- Women in Aerospace
- Cultural exchange events
- Alumni Board

Tess Saxton-Fox

Space Systems

Tim Bretl



BRETL

Aerospace Robotics
- Planning, control, and optimization of robot motion
- Manipulation
- Rehabilitation
- Perception

Siegfried Eggl

APEX

Astrodynamics and Planetary Exploration Lab

Siegfried Eggl
Aerospace Engineering / Astronomy / NCSA

Mike Lembeck

TECHNOLOGY | **LASSI** Laboratory for Advanced Space Systems at Illinois | **Programs**

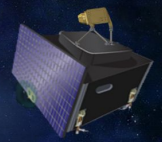
Low-cost Small Satellite Radio

Provide UHF satellite uplink and downlink capability for small satellites in a compact, low-cost package

iEDU

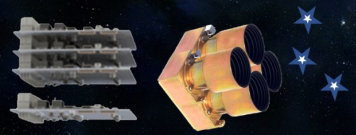
IlliniSat Educational Development Unit allows middle and high school students to participate in the design, assembly, and operation of a CubeSat payload

COSSMo



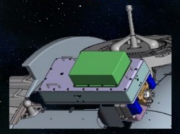
Carruthers Geocoronal Observatory Student Solar Monitor will monitor solar activity from the L1 Lagrange Point

Low-cost Small Star Tracker



Tracker intelligently combines images from camera array using a scalable AI-based compute platform to obtain high signal-to-noise ratio star images for accurate attitude determination

SEAQUE



JPL's Space Entanglement and Annealing QUantum Experiment demonstrates 'integrated optical' source of entangled photon and extends photodiode lifetime via optical annealing

DarkNESS

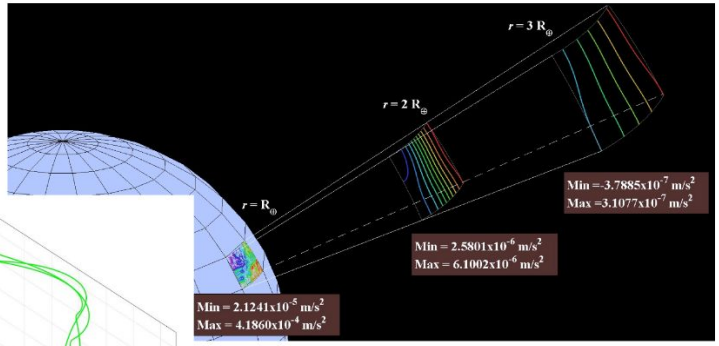
Fermilab's X-ray observations of the galactic center using a cryo-cooled sensor in search of a 3.5 keV signal that may be the signature of dark matter decay.

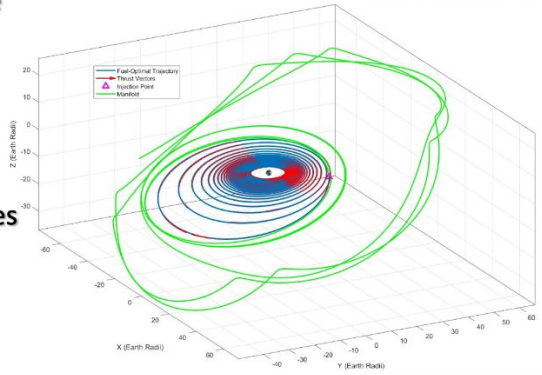
Robyn Woollands

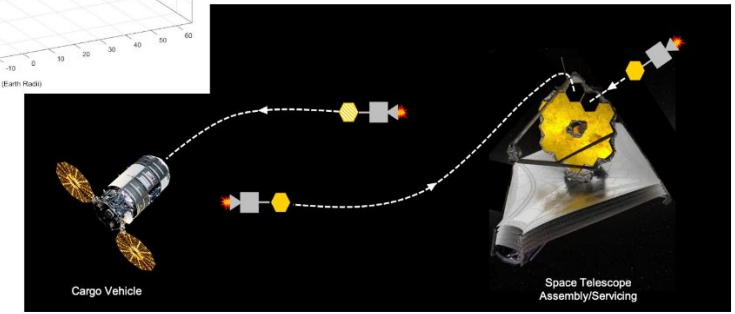
- **High-fidelity Orbit Propagation**
  - Adaptive Picard-Chebyshev (APC) High-Fidelity Orbit Propagation
  - Variable fidelity force model, radially adaptive gravity
  - Neighboring trajectories computed economically using “gravity offset”

- **Low/Medium Thrust Trajectory Optimization**
  - Smoothing thruster and eclipse on/off switches
  - Thruster pointing & anti-collision constraints
  - Smart eclipse continuation

Applications
- Satellite refueling and servicing (LEO & SEL2)
- Cislunar low-thrust trajectory optimization
- Space situational awareness
- Cloud Tomography Mission Design

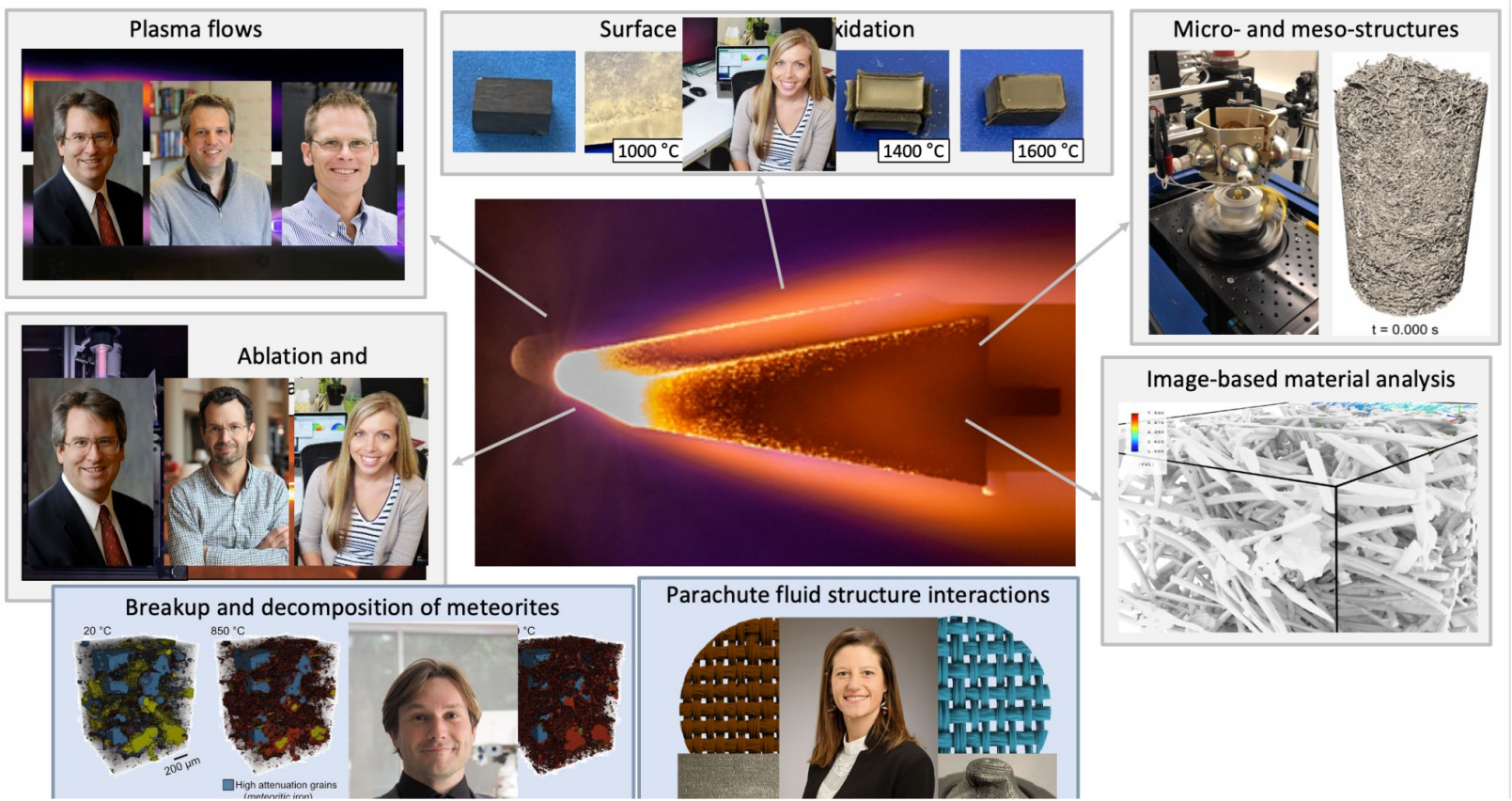






Aerodynamics, Fluid Mechanics, Combustion and Propulsion

Francesco Paneri

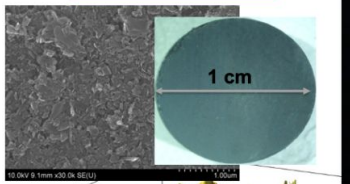

Plasma flows
Surface
xidation
1000 °C
1400 °C
1600 °C
Micro- and meso-structures
t = 0.000 s
Ablation and
Image-based material analysis
Breakup and decomposition of meteorites
20 °C
850 °C
200 µm
High attenuation grains
Parachute fluid structure interactions

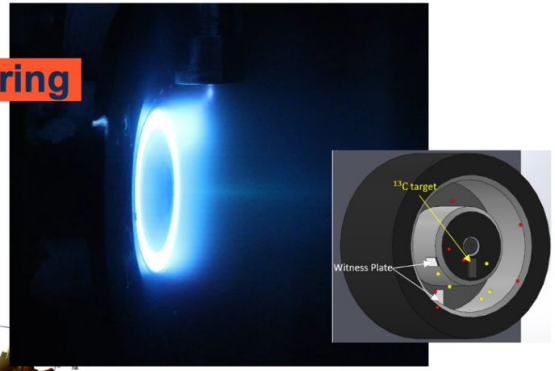
Josh Rovey

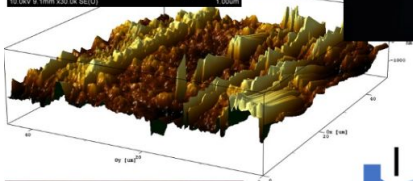
Electric Space Propulsion Lab

Hall Thruster:

- Carbon sputtering & transport

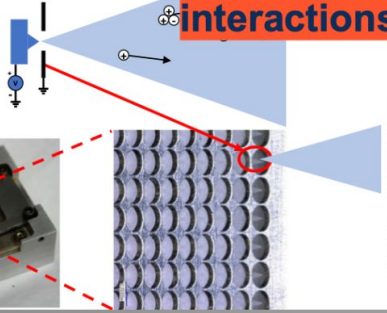


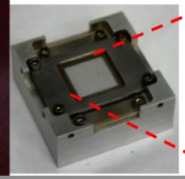


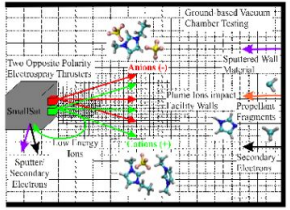


Electrospray:

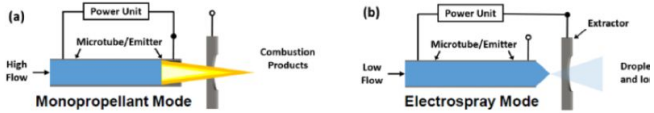
- Plume-material interactions

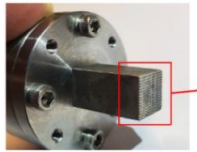


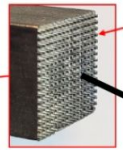


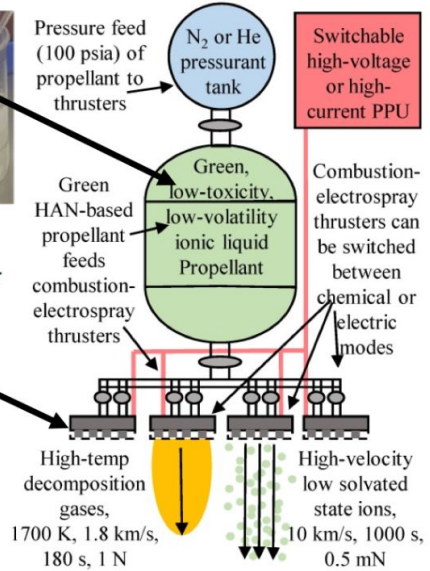


Multimode Propulsion: Chem-Electrospray





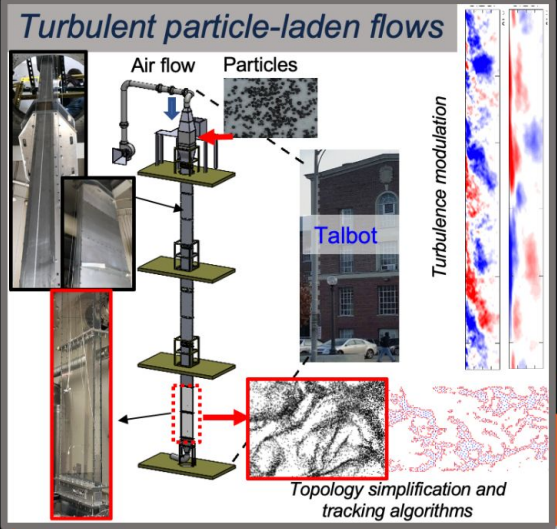




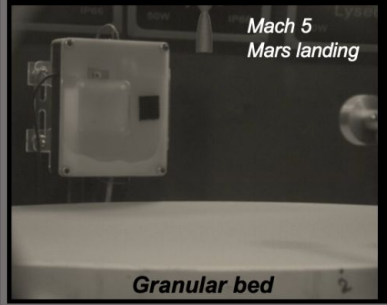
Laura Villafane-Rocha

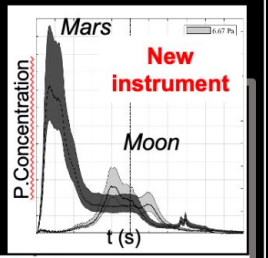
Particle-laden and complex flows

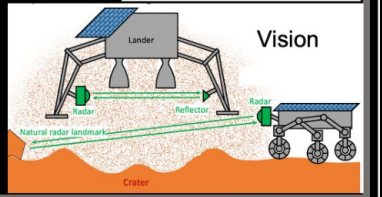
Turbulent particle-laden flows



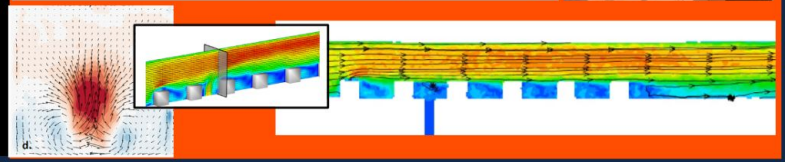
Plume surface interactions



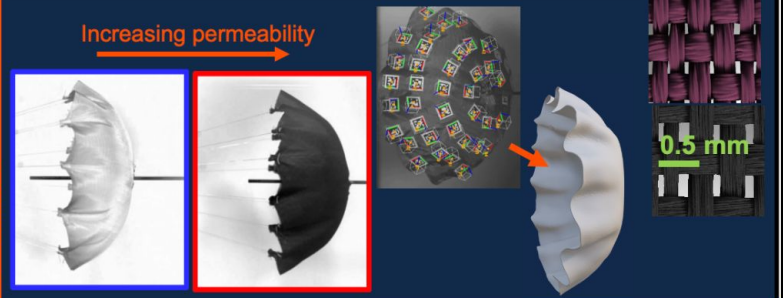




Flow velocimetry via MRI (@Beckman)



Parachute fluid and structural mechanics



AEROSPACE ENGINEERING

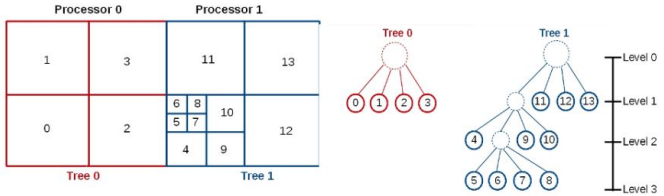
GRAINGER ENGINEERING

Deborah Levin

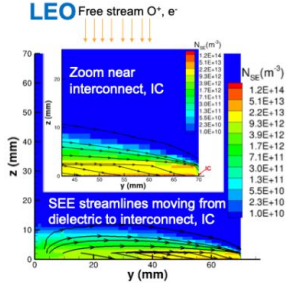
Why high performance particle-in-cell for space plasmas?

- ***Electrons have non-Maxwellian behavior.***
- ***3-D effects important in characterizing plasma instabilities***
- ***Use massively parallel heterogenous CPU/GPU strategies.***

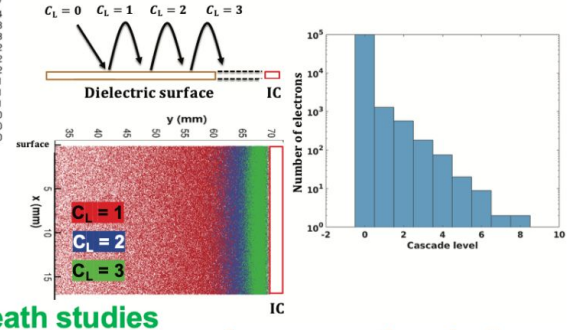
(1) Numerical approach – AMR/Octree



(2) Solarcell arrays – parasitic current snapover

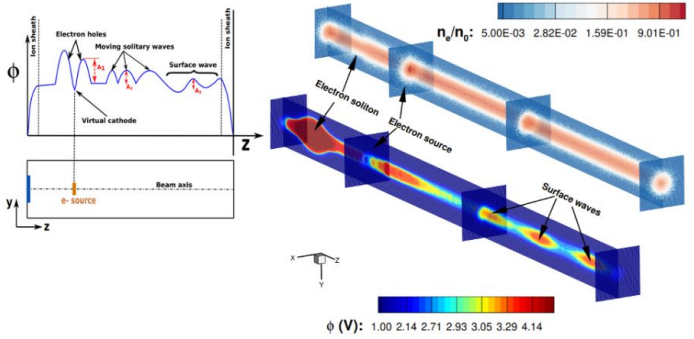


e⁻ s cascading along dielectric surface changes its surface conductivity

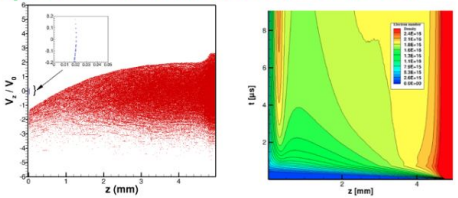


- **3-D CHAOS codes use two linearized Morton-ordered FOTs with own, λ or λ_D for DSMC and PIC simulations**

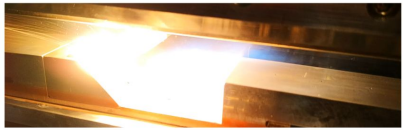
(4) Role of Electrostatic Solitary Waves in Beam Neutralization



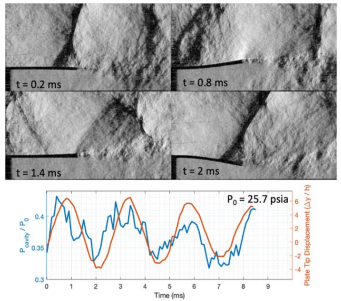
(3) ETC Plasma sheath studies



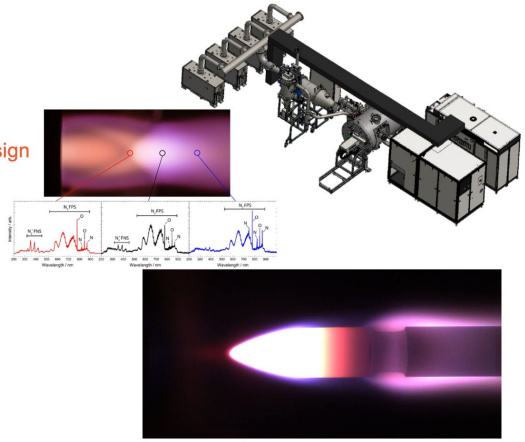
Low energy thermionic electrons accumulate near z = 0 mm surface because of repulsion from virtual cathode



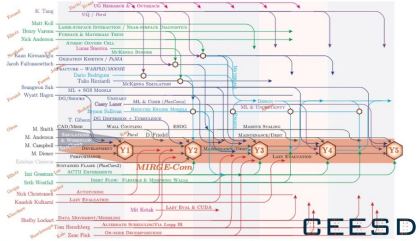
The Center for Exascale-enabled Scramjet Design



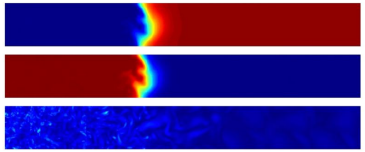
Fluid/Thermal Structure Interactions in High-Speed Flows



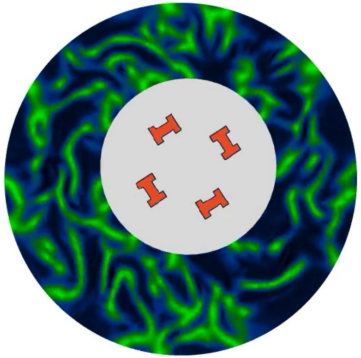
CHESS (Plasmatron X) TPS and Thermal/Chemical Non-equilibrium Flows



The Center for Exascale-enabled Scramjet Design



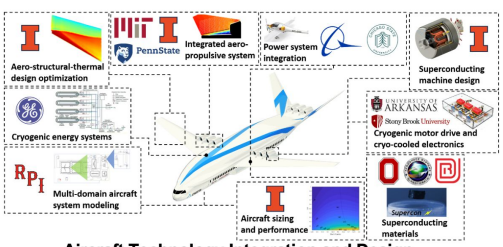
Gov. equation constrained ML training for SGS coupled physics



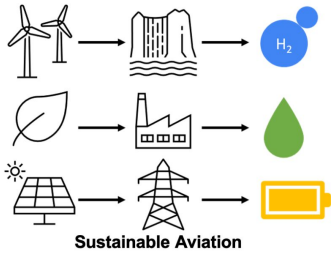
Active suspension dynamics

Greg Elliot

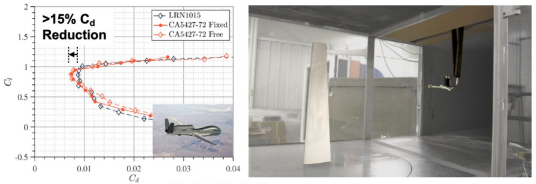
Jon Freund



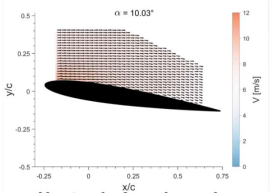
Aircraft Technology Integration and Design



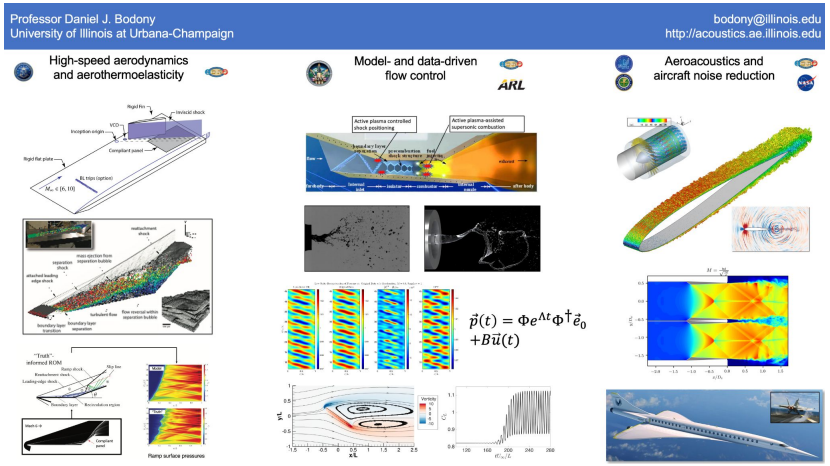
Sustainable Aviation



Air Vehicle Aerodynamics

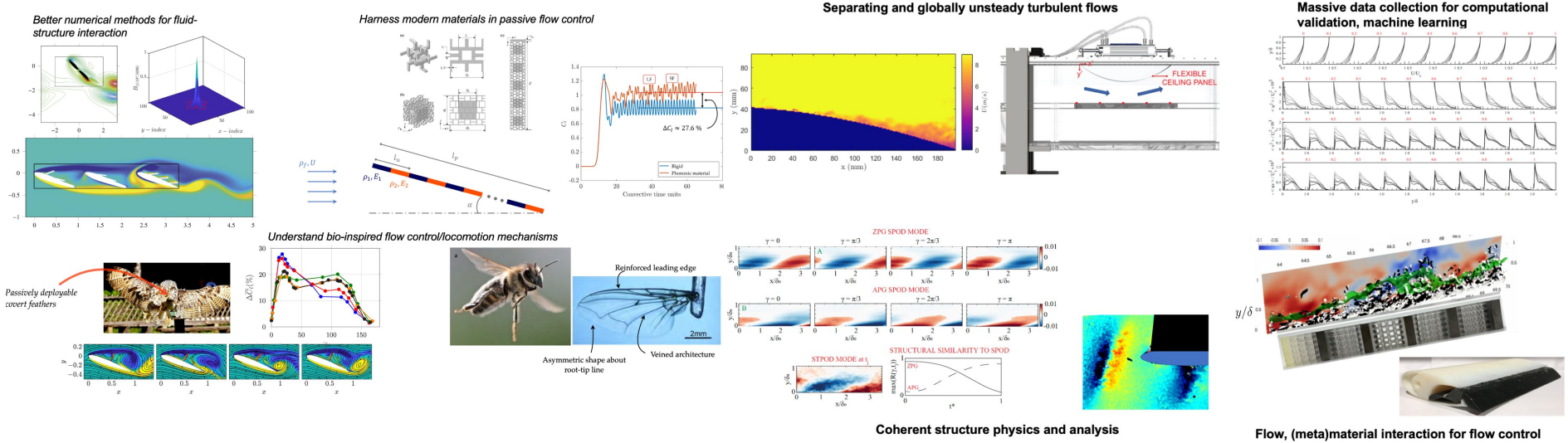


Unsteady Aerodynamics



Phil Ansel

Dan Bodony



Andres Goza Tess Sexton-Fox

Structural Mechanics and Materials

Jeff Baur

Novel Materials

Novel Reactive Polymers
- Structural Resins
- Shape Memory Polymers
- Frontal Polymerized
- Radiation/Snap Cured

Structural Reinforcement
- Fibers
- Nanofillers
- Printed lattices

Multifunctional
- Sensors / Hardening
- Autonomous Response
- EM/Thermal Transport
- Microvascular
- Power/Computation

Printed Composites

Fundamental Understanding → Emerging Industry

Topology Optimization

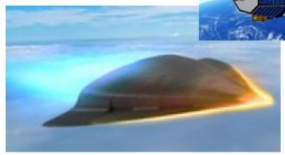
Bio-inspired Morphogenesis

Continuous Fiber Printed Composites

Rapid Model Validation of Adaptive Structures

Multi-functional Structures

Space-based Printing

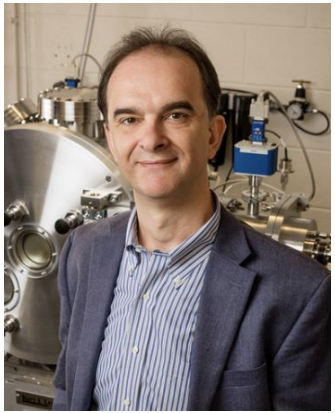


Active Thermal Management

New Adaptive Structures

Low-Cost Attritable Aircraft

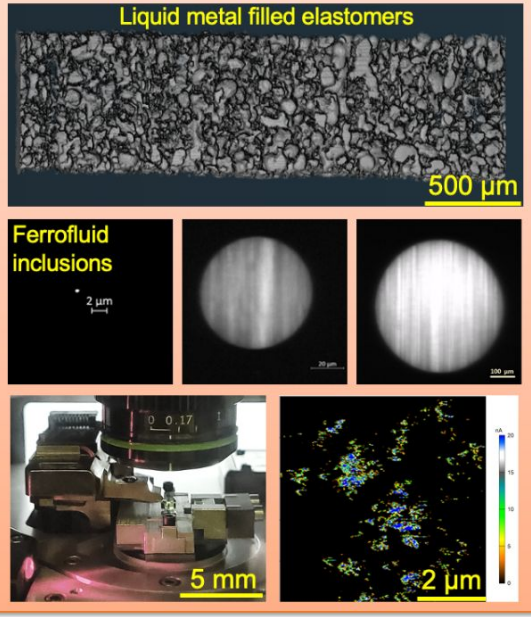
Sustainable Aircraft Structures



Ioannis Chasiotis

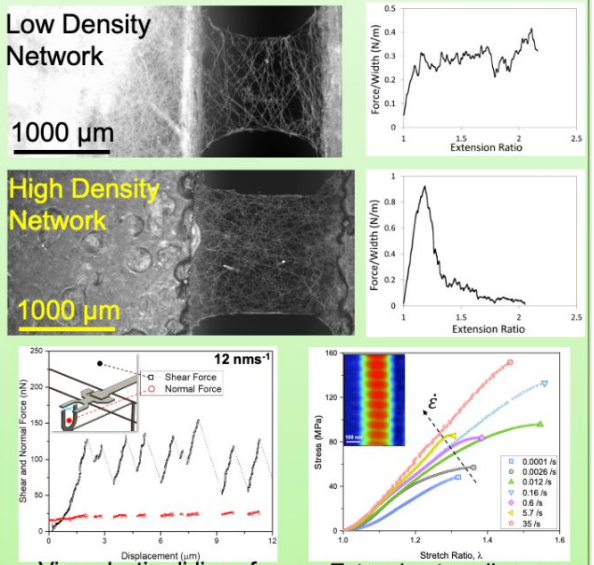
SOFT COMPOSITES WITH LIQUID INCLUSIONS

OBJECTIVE: Investigate multiphysics phenomena in elastomer matrix composites with electrically or magnetically active liquid inclusions.



RANDOM NANOFIBER NETWORKS

OBJECTIVE: Understand fiber-to-fiber interactions and their effects on global mechanical response of random nanofiber networks and their composites.

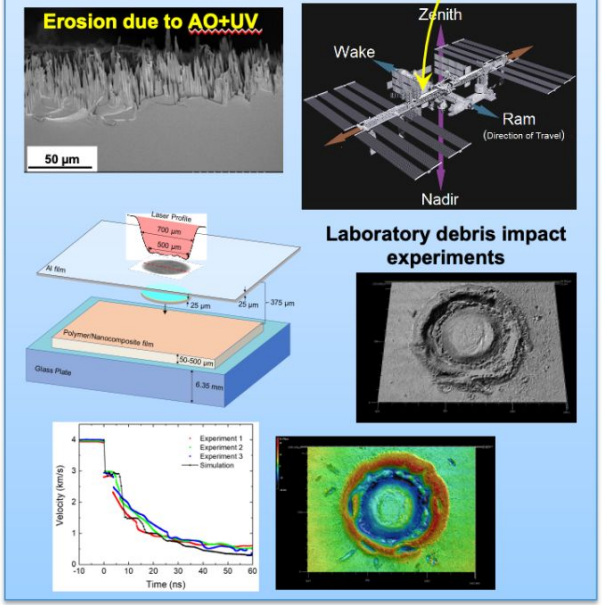


Viscoelastic sliding of nanofibers in a network

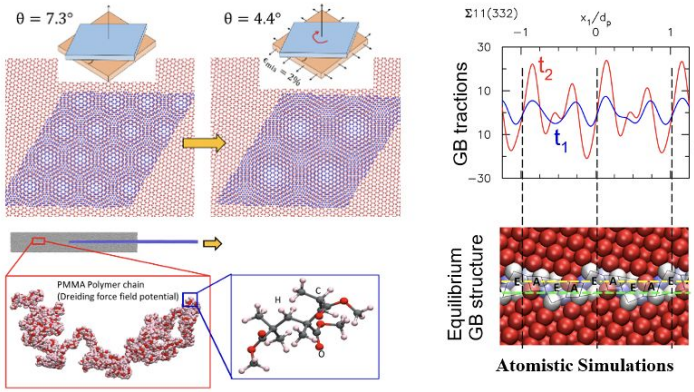
Extension to collagen nanofibrils and networks

SELF-HEALING MATERIALS FOR LEO

OBJECTIVE: Develop strategies for AO+UV erosion mitigation and orbital debris damage repair of polymers in situ in LEO.



Laboratory debris impact experiments



Nanoscale Mechanics of Interfaces

Huck Beng Chew

Philippe H. Geubelle

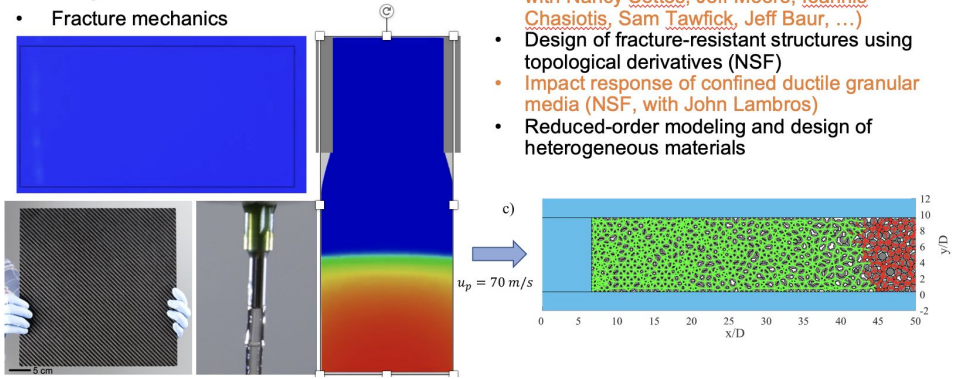
http://aerospace.illinois.edu/directory/profile/geubelle
http://geubelle.aerospace.illinois.edu
geubelle@illinois.edu

Research Interests

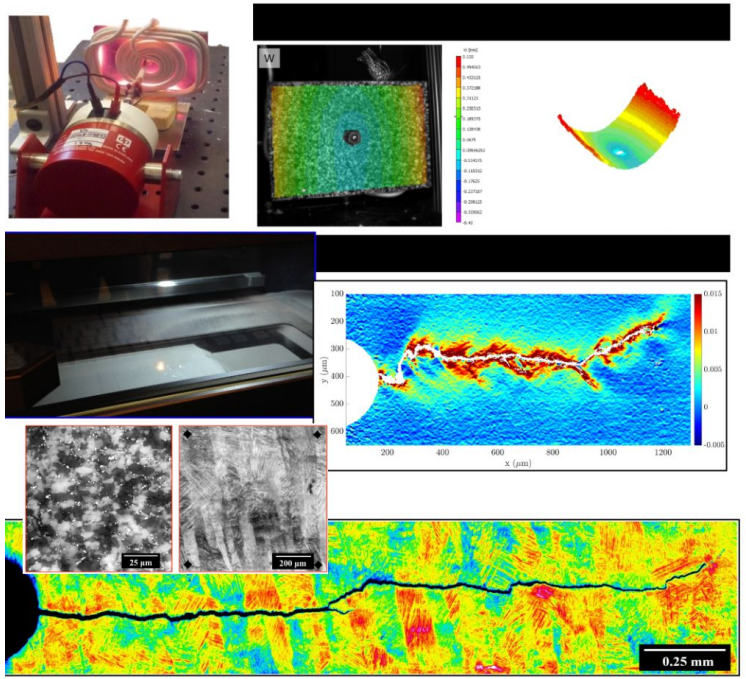
- Faster, energy-efficient manufacturing process for thermoset composites
- Computational design of biomimetic materials
- Development of novel finite element methods
- Multi-scale and multi-physics modeling and design of advanced materials
- Fracture mechanics

Current Projects

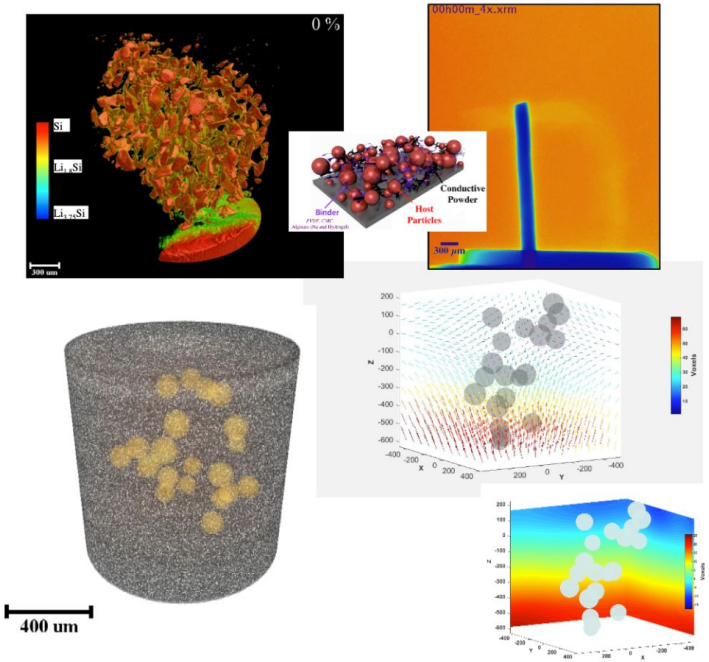
- Rapid, energy-efficient manufacturing of composites using frontal polymerization (FP); 3D printing of thermoset polymer composite; space manufacturing of large composite structures; machine learning-based discovery of new recyclable thermoset polymers made with FP (AFOSR, NSF, DARPA, DOE EFRC, with Nancy Sottos, Jeff Moore, Ioannis Chasiotis, Sam Tawfick, Jeff Baur, …)
- Design of fracture-resistant structures using topological derivatives (NSF)
- Impact response of confined ductile granular media (NSF, with John Lambros)
- Reduced-order modeling and design of heterogeneous materials



Thermoacoustic response of AM metals

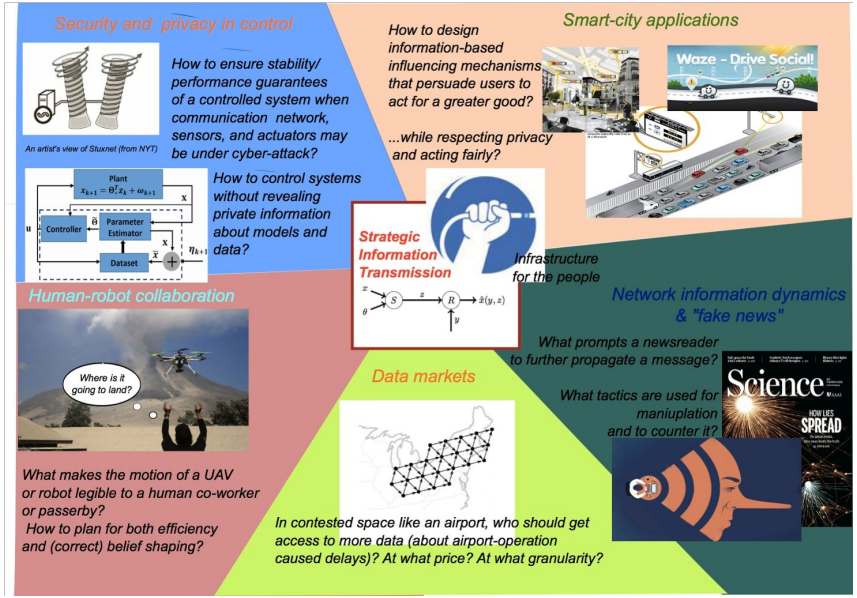


Tomographic investigation of composites



John Lambros

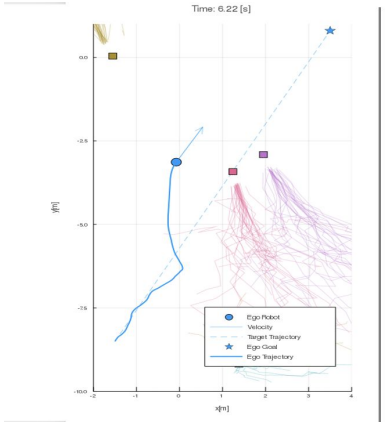
Controls and Dynamical Systems



Cedric Langbort

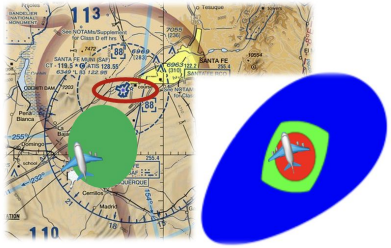
ICON

Risk-Aware Robots

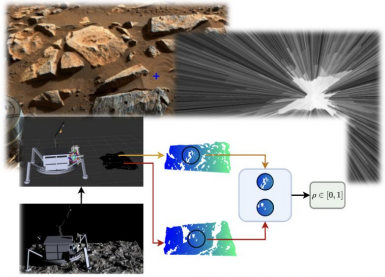


Multi-Agent and System Level Interactions

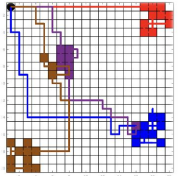
Negar Mehr



Resilience and
Guaranteed Mission Completion



Faster Learning with Side Information

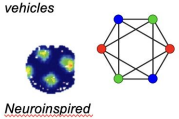


Multi-Agent
Mission Decomposition

Behavior Inference and Belief Manipulation

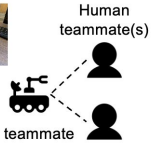
Melkior Ornik

Connected and automated
vehicles

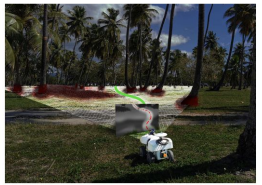


Neuroinspired

Multi-agent Learning



Human-agent Teaming



Robotics and Formal Methods

Hui Tran

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