2021 MSE Expo

Rajat Mittal

Director of Graduate Studies

Mechanical Engineering

November 15, 2021

Agenda

- 5:00 Rajat Mittal
  - Overview – full-time MSE
  - Overview – EP Master's
- 5:20 Mark Savage - Life Design Lab
- 5:25 Faculty Presentations
- 6:00 Closing

JOHNS HOPKINS UNIVERSITY

Full-Time - Degree Requirements

Section A - 8 advisor-approved courses

- 2 must be applied math, numerical analysis, or computational
- 4 (all-course) or 3 (essay) - Mechanical Engineering (530.xxx or 535.xxx)
- Up to 2 - Engineering for Professionals (535.xxx)
- Up to 4 - upper-undergrad level (xxx.4xx only)
- No independent research, graduate research, or special studies.

Section B – choose one

- 2 more courses (530.820 MSE All-Course - Graduate Research can be one)
- Master's Essay – 6 credits, either…
  - 530.821 MSE Essay - Research and Writing
  - 530.822 MSE Essay – Co-Op

Info: https://me.jhu.edu/education/graduate-studies/advising/

Department of Mechanical Engineering

JOHNS HOPKINS WHITING SCHOOL of ENGINEERING

Full-Time - Master's Essay

- **Identify a research advisor**
- **Conduct research or go on co-op**
  - 6 total credits of 530.821 or 530.822 (equivalent of 2 courses);
  - Prepare and submit an essay that summarizes your research (final approval by advisor + one other faculty reader)
  - No essay defense
- **Advantages of MSE Essay**
  - Become part of a research team and/or professional co-op experience.
  - Learn from topic-area experts.
  - Conduct research that might lead to papers and/or conference presentations.
  - Improve your writing/presentation skills.
  - Impress potential employers with your expertise.
  - Improve chances of entering a PhD program.

Info: Section 3.2 of the MechE Master's Advising Manual (page 10).

Full-Time – FAQs - MSE Essay

How do I find an advisor?

- Contact professors in your area of interest
- Contact the Director of Graduate Studies (Rajat Mittal)

What kinds of research projects do MSE student do?

- MSE project is decided by you and your advisor
- MSE research may be a fundamental scientific investigation involving theory an/or experiments and/or computational modeling or it might involve experimental design and/or testing of a device.

How long is the MS Essay?

- There is no recommended length. The essay is a summary of your work. Your advisor will usually guide you in the writing.

Research can be open-ended. What if I cannot achieve my research objectives even after 6 credits of research? Will that delay my graduation?

- No! The MS essay is written, submitted and approved at the end of 6 credits of MSE research. As long as your advisor is satisfied that your research effort was appropriate and you prepare an essay that is approved, you are done.

For the 5-Yr MSE program, can I do an essay and finish in 1 year?

- Yes! Talk to potential advisors in your Senior year to start planning.

Is there funding available for MSE students who conduct research?

- Most MS research is unfunded.

Info: https://me.jhu.edu/education/graduate-studies/masters-program/

EP – Master's - All-Course Requirements

Ten courses – finish in 5 years or less

- 1 Math
- 2 Core "Group 1" courses
- 3 "Group 1" or "Group 2" of focus area
- 4 Technical Electives
  - EN.535.820 Master's Graduate Research can substitute for 1 Technical Elective
  - Can work with advisor, a full-time Mechanical Engineering professor, or EP instructor

Info: https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/

EP – Master's - Thesis Requirements

Eight courses and a Thesis – finish in 5 years or less

- **Courses**
  - 1 Math
  - 2 Core "Group 1" courses
  - 3 "Group 1" or "Group 2" of focus area
  - 2 Technical Electives
    - At least 1 from core engineering discipline
    - Up to 1 from selected engineering alternate option
- **Thesis**
  - Submit proposal any time but no later than 3rd to last semester of 5-year limit
  - Enroll in 535.820 Master's Graduate Research and 535.821 Master's Thesis Writing
  - Work with advisor, full-time Mechanical Engineering professor, EP instructor, or APL research staff

Info: https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/

EP – FAQs – Master's Thesis

How do I find an advisor?

- Contact professors in your area of interest
- Work with academic advisor and program chair.

What kinds of research projects do MSE student do?
How would remote EP students and those working full-time be able to do the thesis?

- Students in the Baltimore region or have access to equipment at their workplace can work on experimental projects.
- Students from other areas or without experimental equipment access work on theoretical or computational projects.
- The thesis advisor will help you create a thesis plan.

How long is the MS Essay?

- There is no recommended length. The essay is a summary of your work. Your advisor will usually guide you in the writing.

What is the expected level of research complexity and level of involvement?

- Full-time Homewood and "part-time" EP students would have the same level of rigor and vigor. Your advisor and program chair will help guide the thesis essay expectations.

Are the same opportunities available to EP students and well as full-time Homewood students?

- Faculty ultimately have the discretion of who they accept to do research for a thesis in their labs.

Would doing a thesis change the EP degree from "Master of Engineering" to "Master of Science in Engineering"?

- No. The degree title is independent of whether or not a thesis is completed.

Info: https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/

Department of Mechanical Engineering

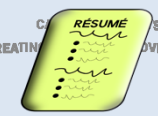
JOHNS HOPKINS WHITING SCHOOL of ENGINEERING

LIFE DESIGN LAB
WSE GRADUATE AFFAIRS OFFICE

JOHNS HOPKINS UNIVERSITY

Educator for Engineering Masters Students
Mark Savage msavag16@jhu.edu

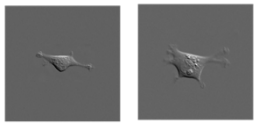
FOR DISCUSSIONS / CONSULTATIONS ABOUT CAREER AND/OR JOB SEARCH FOCUSED ISSUES



REGISTER ON HANDSHAKE TO MAKE APPTS, APPLY FOR JOBS, SIGN-UP FOR EVENTS:
https://handshake.jhu.edu

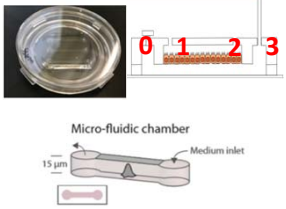
Prof. Sean Sun
Cell Mechanics (Biology Meets Mechanics)

Fundamental roles of mechanical forces in cell and tissue movement, morphogenesis, and disease



Learn: microscopy, cell culture, genetic engineering techniques, image analysis and device building

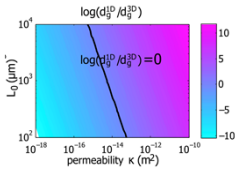
Organ-on-chip, recapitulation of biological system in micro-devices



Learn: microfluidic methods, tissue and organ culture, biotechnology questions and commercial opportunties

Mathematical model: quantitative theories of major cell functions

$$V_{\text{cell}} = J^f_{\text{actin}} + J^f_{\text{water}} + \theta_n v^f_n + \theta_c v^f_c$$



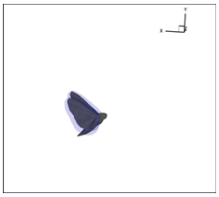
Learn: fluid mechanics, solid mechanics, dynamical systems and control theory.

Flow Physics and Computation Lab (FPCL)

PI: Rajat Mittal

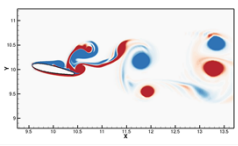
Themes

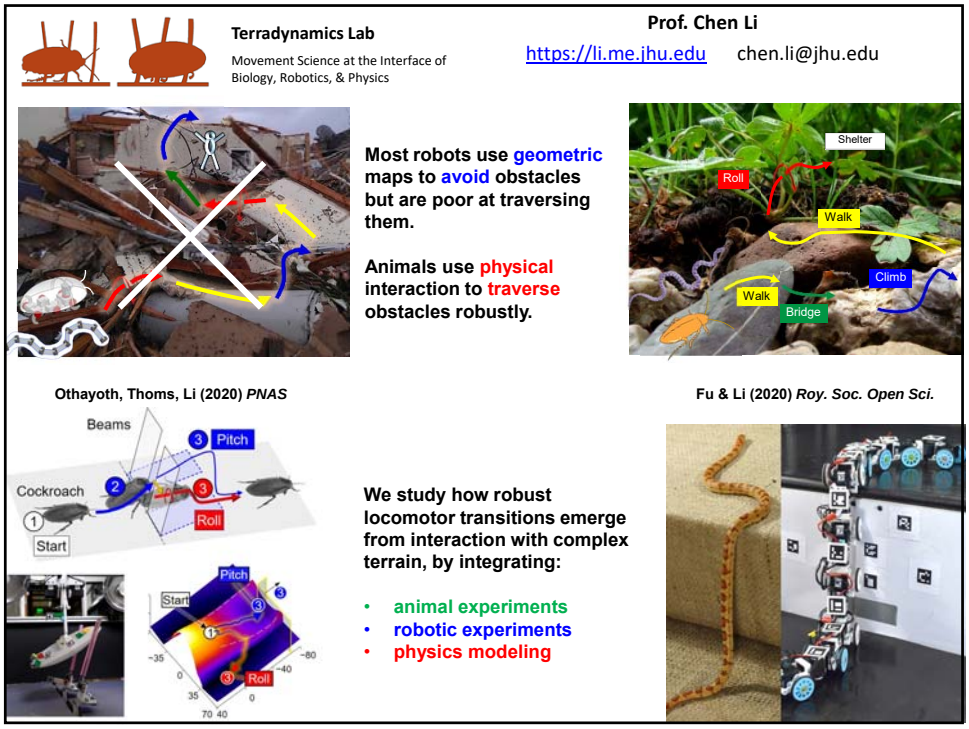
- CFD method development
- Moving Boundaries
- Fluid-Structure Interaction
- Acoustics
- Flow Control

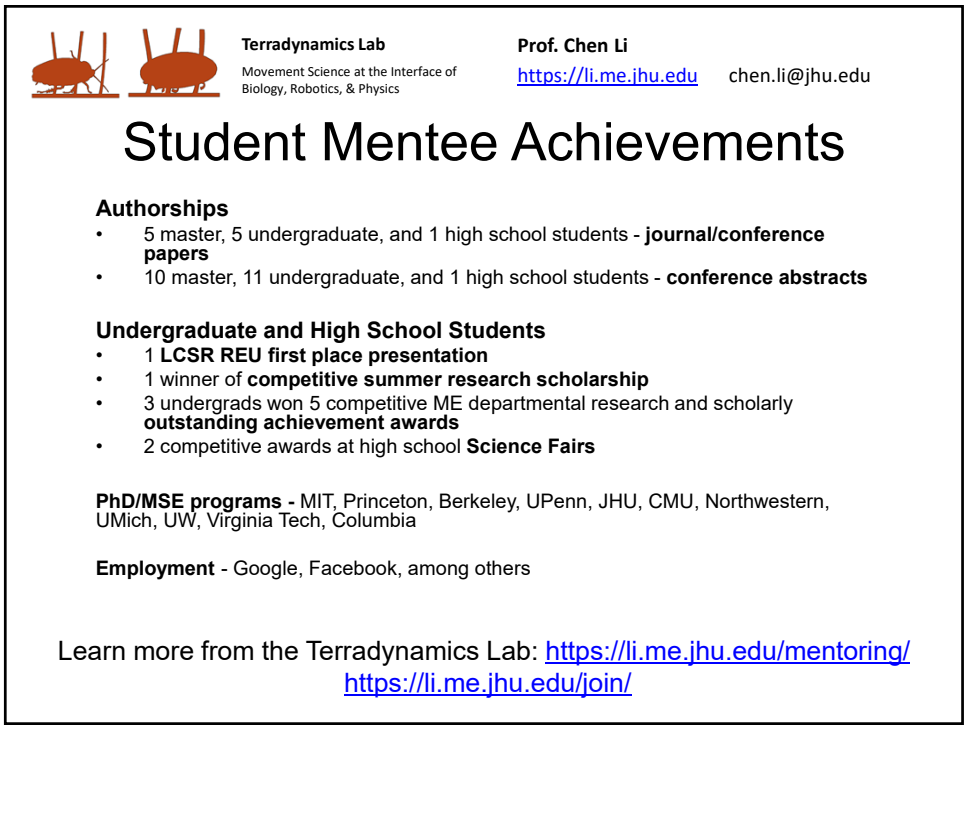


Application Areas

- Active control of flow separation
- Rough Wall BLs
- Flow-Induced Flutter
- Biological Locomotion
- Cardiovascular Biomechanics
- Bioacoustics




Terradynamics Lab
Movement Science at the Interface of Biology, Robotics, & Physics
Prof. Chen Li
https://li.me.jhu.edu chen.li@jhu.edu
Most robots use geometric maps to avoid obstacles but are poor at traversing them.
Animals use physical interaction to traverse obstacles robustly.
Shelter
Roll
Walk
Climb
Walk
Bridge
Othayoth, Thoms, Li (2020) PNAS
Fu & Li (2020) Roy. Soc. Open Sci.
Beams
Pitch
Cockroach
Roll
Start
We study how robust locomotor transitions emerge from interaction with complex terrain, by integrating:
animal experiments
robotic experiments
physics modeling


Terradynamics Lab
Movement Science at the Interface of Biology, Robotics, & Physics
Prof. Chen Li
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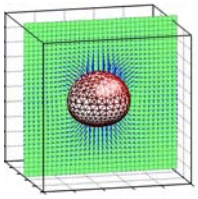
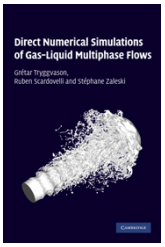
Student Mentee Achievements
Authorships
5 master, 5 undergraduate, and 1 high school students - journal/conference papers
10 master, 11 undergraduate, and 1 high school students - conference abstracts
Undergraduate and High School Students
1 LCSR REU first place presentation
1 winner of competitive summer research scholarship
3 undergrads won 5 competitive ME departmental research and scholarly outstanding achievement awards
2 competitive awards at high school Science Fairs
PhD/MSE programs - MIT, Princeton, Berkeley, UPenn, JHU, CMU, Northwestern, UMich, UW, Virginia Tech, Columbia
Employment - Google, Facebook, among others
Learn more from the Terradynamics Lab: https://li.me.jhu.edu/mentoring/
https://li.me.jhu.edu/join/

Computational Studies of Multiphase Flows

Gretar Tryggvason's Group



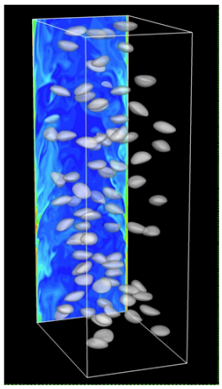


We study multiphase flows, such as flows with bubbles and drops, atomization, boiling, etc. by fully resolved numerical simulations.

Possible MSE projects include using already existing codes to examine various physical problems or writing codes to explore new ideas for data processing. Examples include:

X. Chen, J. Lu and G. Tryggvason. "Numerical Simulation of self-propelled non-equal sized droplets." Physics of Fluids. 31 (2019), 052107.

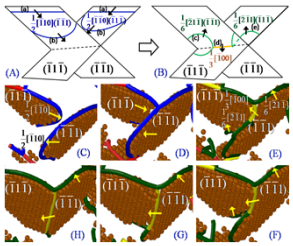
Y. Qi, J. Lu, R. Scardovelli, S. Zaleski, and G. Tryggvason. "Computing Curvature for Volume of Fluid Methods using Machine Learning." Journal of Computational Physics. 377 (2019), 155-161.



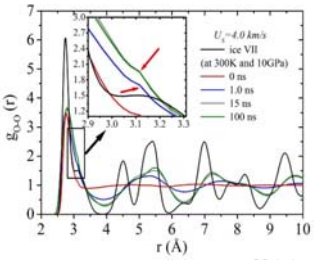
Profs. G. Tryggvason and J. Lu

Materials @ Extremes

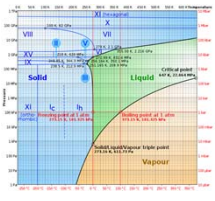
- Nilanjan Mitra
(nmitra1@jhu.edu)

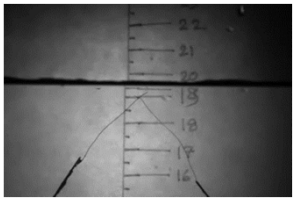


Hirth-lock formation → shock induced plasticity in Cu

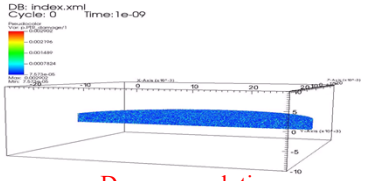


Shock induced phase transition in water

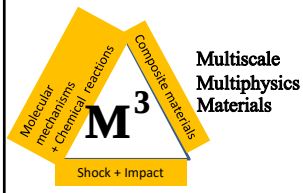




Underwater spark discharge



Damage evolution + Ejecta Spray + Bulge/Penetration

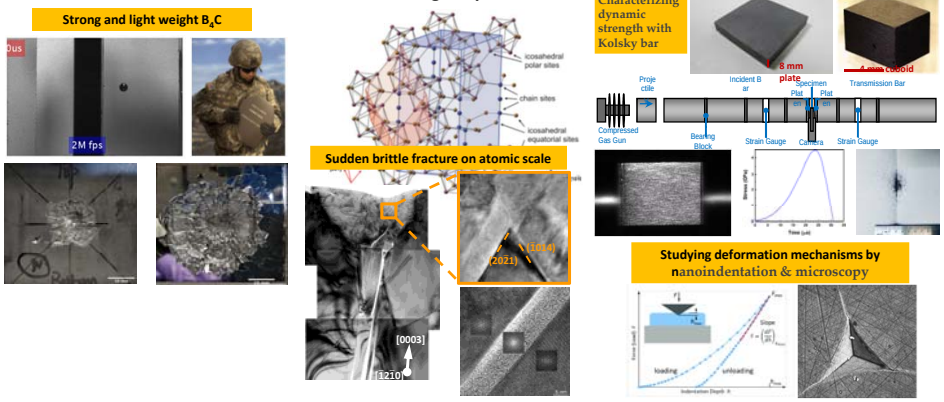


Multiscale Multiphysics Materials

Ramesh Lab: Making of Armor Ceramics

Focus: **Improving dynamic performance of boron carbide (B_4C) ceramics for protective applications**

Approach: **Unraveling the relationship between high-rate mechanical properties and microstructure through experiments**



JOHNS HOPKINS UNIVERSITY

HEMI HOPKINS EXTREME MATERIALS INSTITUTE

Combining Machine Learning, Multiscale Modeling, and in situ Experiment to Design Materials with Superior Properties

Prof. Jaafar El-Awady
jelawady@jhu.edu

Presenter: Ali Rida

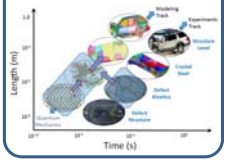
Micro-structure → Property Prediction

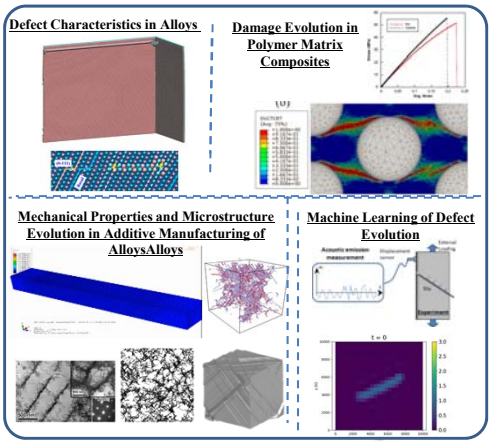
Multiphysics Multiscale Modeling

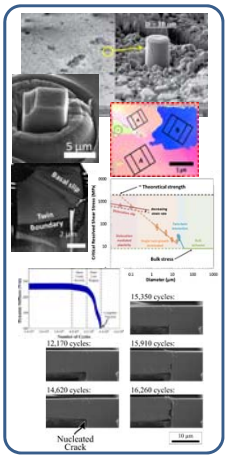
Location Specific In situ High Temp. Testing of Metals

Overview:

- Our group couples ***machine learning*** and ***physics-based multiscale modeling*** tools to design and predict the thermo-mechanical properties, deformation and failure of materials.
- We also develop advanced microscale experiments to: quantify location based properties of advanced metals and alloys.







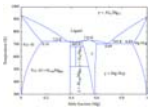
Defect Engineering of Structural Materials

Laszlo Kecskes' Group

Focus: improving materials for engineering applications
Approach: study underlying physical mechanisms and understand processing-structure-property relationships
Projects: thermomechanical processing and characterization of Mg alloys, additive manufacturing of refractory alloys, and process modeling

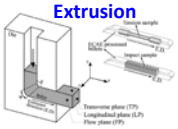
Thermomechanical Processing of Lightweight Alloys

Mg-Al Model Alloy System

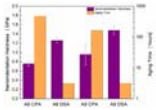


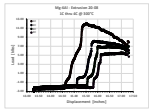
SPD* Processing

Equal Channel Angular Extrusion



Mechanical Properties

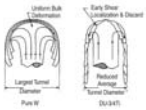




Mechanism-Based Deformation Behavior

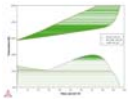
SPD – Severe Plastic Deformation

Additive Manufacturing of Refractory Alloys



Deformation Engineering

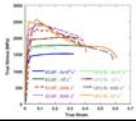
Alloy System Design



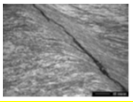
Laser Powder Bed Fusion

Property Characterization

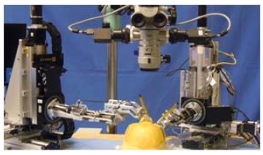
Mechanical



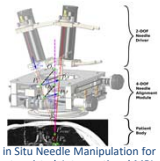
Microstructural



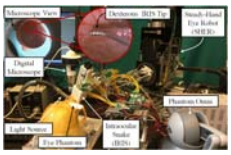
Contact Information: lkecske1@jhu.edu



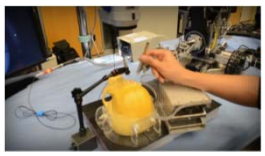
Robot-Assisted Retinal Surgery



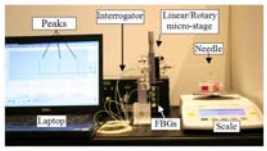
Safe in Situ Needle Manipulation for Robot-assisted Interventional MRI



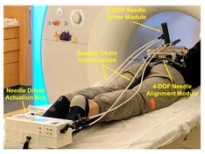
Intraocular Snake-like Robot



Force-sensing Tools for Robot-Assisted Retinal Surgery



Real-Time Shape Sensing-Based for Flexible Needles



Body-mounted Robot for MRI-guided Percutaneous Interventions

The **Advanced Medical Instrumentation and Robotics Research Laboratory (AMIRo)** conducts research to aid and support the robotic assisted medical technology encompassing medical diagnosis and therapy, and clinical research. The main goal is to create the future medical robots and devices that will help clinicians to deliver earlier diagnosis and less invasive treatments at lower cost and in shorter time.

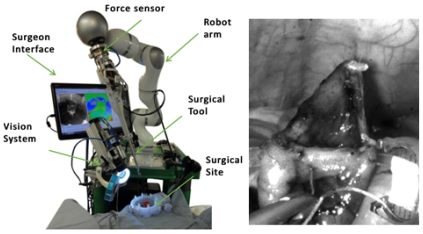
Iulian Iordachita Ph.D., Director
iordachita@jhu.edu

Intelligent Medical Robotic Systems and Equipment (IMERSE) Lab
Prof. Axel Krieger, email: axel@jhu.edu

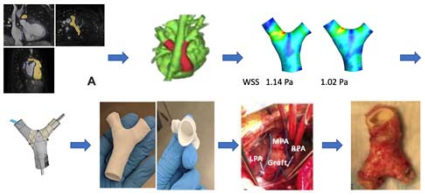
Research Vision

- Replace critical portions of manual surgery/intervention with robotic precision
- Give physicians access to best images during surgery/intervention
- Prepare physicians with realistic plans and access to relevant patient information
- To reduce complications
- Accelerate learning curve
- To enable previously unimaginable tasks

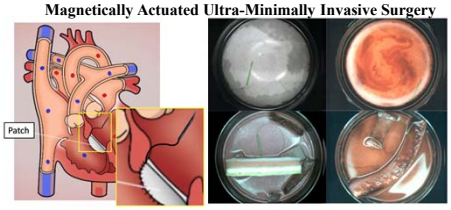
Smart Autonomous Surgery



3D Printing Patient Specific Vascular Graft



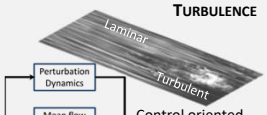
Magnetically Actuated Ultra-Minimally Invasive Surgery



Research Information from other Professors unable to join us today…

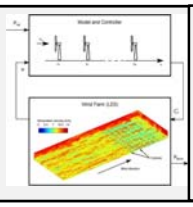
Gayme group projects

Mechanisms of Wall-bounded Turbulence



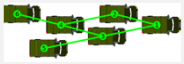
Control oriented models of transition and turbulence

Wind Farm Modeling and Control



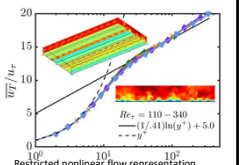
Engineering models for wind farm design and controllers to enable wind farms to provide grid services

Optimizing Performance of Networked Systems



Master's Essay projects staring Spring 2022

- High Reynolds number reduced order wall-turbulence modeling tools
  - Model validation through simulation over a range of conditions
  - Characterizing the role of the physics in refining the model reduction approach
- Research tasks and required skills
  - Simulations of channel flow using existing codes (CFD)
  - Analysis of results (Matlab and Python)
  - Modification of tools to simulate improved models based on findings (modeling)



Restricted nonlinear flow representation comprising a streamwise constant large-scale interacting with dynamically restricted perturbations reproduces salient flow features at vastly reduced computational costs.

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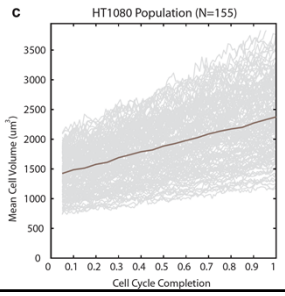
Contact Prof. Dennice Gayme at dennice@jhu.edu.

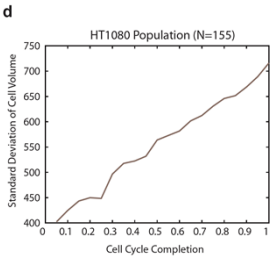
Dynamics of Cell Grown & Division

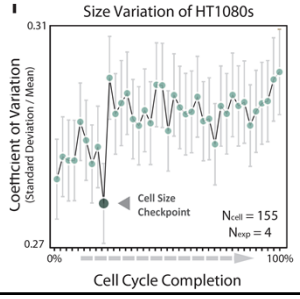
Noah J Cowan and Sean X Sun

ncowan@jhu.edu and ssun@jhu.edu

- Goal: understand cell-cycle dynamics using dynamical systems theory
- Approach:
  - Create simplified models to explain cell growth
  - Make model-based predictions for experiments
  - Analyze cell-cycle data from the Sun laboratory
- Who should consider this?
  - Required: hardworking, ***curious*** student with solid background in dynamical systems
  - Desired: skilled in dynamical system simulation in Matlab, Mathemica, or Python







MSE Essay Research Opportunities in 2021-2022

Name	Energy & Environment	Fluid Mechanics & Thermal Sci.	ME in Biology and Medicine	Mechanics and Materials	Micro/Nano Scale Science	Robotics, Systems, Control
Mehran Armand			X			X
Jeremy Brown			X			X
Noah Cowan			X			X
Jaafar El-Awady				X		
Dennice Gayme	X	X				X
Ryan Hurley				X		
Claire Hur		X	X		X	
Iulian Iordachita			X			X
Chen Li			X			X
Laszlo Kecskes		X		X		
Axel Krieger						X
Nilanjan Mitra		X		X	X	
Rajat Mittal	X	X	X			
Vicky Nguyen			X	X		
Rui Ni	X	X	X			
KT Ramesh			X	X		
Nathan Scott	Design					
Jung Hee Seo		X	X			
Sean Sun			X			
Gretar Tryggvason	X	X				
Feng Zhu				X		

Best of luck to you this year!

Questions? Contact Prof. Rajat Mittal, mittal@jhu.edu

Department of Mechanical Engineering

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