IOWA STATE UNIVERSITY
Center for Multiphase Flow Research and Education

Message from the Director

Our semester is off to a great start and ISU's total enrollment this year is just under 33,400. The College of Engineering is the largest college on campus with a total enrollment of almost 8,800. That means there are a lot of students with a potential interest in multiphase flows. Part of our job as faculty affiliated with CoMFRE is to train our students in the many facets of multiphase flows. You can gauge our progress by attending our graduate student and post-doc poster competition as part of our annual meeting Oct. 28-29 (details below). I encourage you to attend, and look forward to seeing you in Ames.

With kind regards,

Ted

Theodore (Ted) J. Heindel
Director, Center for Multiphase Flow Research and Education
University Professor
Bergles Professor of Thermal Sciences

CoMFRE Symposium & IAB Meeting, October 28-29, Ames, IA

Registration is open for the 2019 CoMFRE Symposium and Member Meeting, October 28-29! Industry members will receive updates on shared research and meet with CoMFRE faculty and students to discuss future research and goals for the center. In addition to presentations and a poster competition, there will be ample opportunities for networking and interaction among industry representatives, faculty, graduate students and postdocs.

- October 28, 3-5 pm: closed meeting, CoMFRE members only.
- October 28, 6-9 pm: open meeting; student poster competition and reception at 6 pm, dinner at 7 pm.
- October 29, 8 am - 3 pm: open meeting; posters on display throughout.

Feel free to contact Jan Seibel (jseibel@iastate.edu) if you would like more information on our annual meeting. A draft full Agenda and additional information is posted on our website. Use this link to register by October 14.

CoMFRE and CoMFRE Affiliates in the News

- **CoMFRE affiliates named Anderlik Professors:** Paul **Durbin**, professor of Aerospace Engineering, and Baskar **Ganapathysubramanian**, professor of Mechanical Engineering, were appointed to Joseph and Elizabeth Anderlik Professorships in Engineering. https://news.engineering.iastate.edu/2019/08/05/three-cyclone-engineers-named-anderlik-professors/.
- **The intersection of research and education:** Shankar **Subramaniam**, professor of mechanical engineering, and collaborators from Michigan and Minnesota have received NSF funding for their research on heat transfer in a mixture of solids and gases. This fundamental research will serve as a building block for many additional research projects, and the team will create a toy-sized model of the heat transfer process to teach to students in middle school and high school. https://news.engineering.iastate.edu/2019/08/28/the-intersection-of-research-and-education-new-nsf-award-for-subramaniam/.
- **Synergy between research and application:** Travis **Sippel**, associate professor of mechanical engineering, and his team are applying microwave energy to rocket propellant and other combustibles to understand how electromagnetic fields, specifically microwave fields, can be used to dynamically control the combustion of propellants and pyrotechnics. This research is tested by the CyRoc student rocketry team when they build a rocket to launch in a competition in New Mexico each spring. https://news.engineering.iastate.edu/2019/09/04/synergy-

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between-research-and-application-project-collaboration-with-comfre-and-student-organization/.

- **Attinger's blood spatter analysis advances forensic science:** A multi-institution team lead by Daniel **Attinger** is advancing blood spatter analysis to improve forensic science. This work was recently highlighted in an on-line article by PBS NOVA. The article discusses how fluid mechanics can be used in crime scene blood spatter analysis. The full article can be found here: https://www.pbs.org/wgbh/nova/article/forensics-bloodstain-pattern-analysis/.
- **Investigating icing and deicing of wind turbine blades:** A research group led by Hui **Hu** will use the university's Icing Research Tunnel to study the effect of icing of wind turbine blades. Ice accumulation on turbine blades can significantly reduce power production. The team will also study ways to prevent or delay ice formation on the blades. https://www.news.iastate.edu/news/2019/09/23/turbineicing

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Recent Degrees Granted to Students Working on Multiphase Projects

- Jingshuai Guo, "Neuronal Sensing via Inkjet Printing of Biocompatible Graphene", MS, Advisors: Nicole **Hashemi** and Reza Montazami
- Rajeendra Pemathilaka, "Placenta-on-a-Chip: A Microfluidic Platform to Study the Drug Transport Across the Human Placental Barrier" PhD, Advisor: Nicole **Hashemi**
- Alex Wrede, "Controlled Cavitation Design and Investigation of its Effect in Traumatic Brain Injuries", PhD, Advisor: Nicole **Hashemi**

New CoMFRE Faculty Affiliates

The following faculty have joined CoMFRE as faculty affiliates. A full list of CoMFRE faculty affiliates can be found here: https://comfre.iastate.edu/team-2/.

- **Hui Hu**, Martin C. Jischke Professor in Aerospace Engineering. Dr. Hu has been at Iowa State since fall 2004. He has research interests in aircraft icing physics and anti-icing/de-icing; heat transfer of gas turbines; wind energy and wind turbine aeromechanics; unmanned-aerial-vehicle (UAV) aerodynamics; micro-flows and micro-scale heat transfer in microfluidics or “Lab-on-a-Chip” devices; wind engineering and flow-structure interactions of built structures in violent winds. Further information about his technical background and recent research projects is available at http://www.aere.iastate.edu/~huhui/.
- **Michael Olsen**, Professor in Mechanical Engineering. Dr. Olsen’s area of expertise is experimental fluid mechanics. In his laboratory, his students primarily use non-intrusive laser-based measurement techniques, such as particle image velocimetry, microscopic particle image velocimetry, and planar laser induced fluorescence to investigate a wide variety of complex fluid flows. His research projects have included turbulent mixing in both microscale and large-scale chemical reactors, turbulent flow and noise generation in rotating machinery (such as superchargers and cooling fans), multiphase flow in algae bioreactors, and droplet breakup and coalescence in multiphase flows. https://www.me.iastate.edu/faculty/profile/mgolsen

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Recent and Upcoming CoMFRE Seminars

- Wednesday, September 25, 10:00 am: **Kimberly Moss**, Biological/Pre-Medical Illustration, Department of Art and Visual Culture, Iowa State University; Topic: “Thinking About Visuals, Visuals About Thinking: How to Communicate Your Work in a Poster Presentation”
- Wednesday, October 16, 10 am: **Victor Calo**, Curtin University, Perth, WA, Australia; Topic: “Multiscale, Multiphysics, and Multiresolution Computing in Science & Engineering”
- Wednesday, October 23, 10 am: **Jinhui Yan**, Civil & Environmental Engineering, University of Illinois, Urbana-Champaign; Topic:

"Computational Thermal Multiphase Flows with Applications to Metallic Additive Manufacturing"

Recently Awarded Publicly-Funded Grants

Feel free to contact the PI directly if you have any questions on the projects below.

- "Innovative Multiphase Models for Enhanced Blast Effects", Rodney **Fox**; Funding Agency: DOD SBIR; New Funding amount: $25,000.
- "Collaborative Research: QRM: Microstructure Manifold Analysis Using Hierarcical Set of Morphological, Topological, and Process Descriptors", Baskar **Ganapathysubramanian**; Funding Agency: NSF; New Funding Amount: $231,026.
- "Predictor of Aircraft Structural Loads Due to Buffet", Ming-Chen **Hsu**; Funding Agency: NAVAIR SBIR; New Funding Amount: $43,610.
- "Collaborative Research: A Fundamental Study on Supercooled Large Droplets: Impacting, Splashing, Surface Water Dynamics, and Ice Accretion", Hui **Hu**: Funding Agency: NSF; New Funding Amount: $281,156.
- "Wind Turbines in Cold Winter: Icing Physics and Novel Strategies for Wind Turbine Icing Mitigation", Hui **Hu**; Funding Agency: Iowa Energy Center, the State of Iowa; New Funding Amount: $303,587.
- "On Command Pyrotechnic Light Emission Control through Electromagnetic Irradiation", Travis **Sippel**, James **Michael**, Shankar **Subramaniam**; Funding Agency: Naval Surf. Warfare Car, Crane; New Funding Amount $149,925.

Recent Journal Publications

Note that CoMFRE affiliates are identified by **bold** names.

- Chausalkar, A., S.-C. **Kong**, and J.B. **Michael**, "Multicomponent Drop Breakup During Impact with Heated Walls," *International Journal of Heat and Mass Transfer*, 141:685-695, 2019.

- **Fox**, R. O., “A Kinetic-Based Hyperbolic Two-Fluid Model for Binary Hard-Sphere Mixtures,” *Journal of Fluid Mechanics* 877:282-329, 2019.
- Gao, L.Y., Y. Liu, L.Q. Ma, and H. **Hu**. "A Hybrid Strategy Combining Minimized Leading-Edge Electric-Heating and Superhydro-/Ice-Phobic Surface Coating for Wind Turbine Icing Mitigation”, *Renewable Energy*, 140:943-956, 2019. https://doi.org/10.1016/j.renene.2019.03.112
- Gao, L.Y., R. Veerakumar, Y. Liu, and H. **Hu**. "Quantification of the 3D Shapes of the Ice Structures Accreted on a Wind Turbine Airfoil Model”, *Journal of Visualization*, 22(4):661–667, 2019. https://doi.org/10.1007/s12650-019-00567-4
- Guo, J., A.E. Niaraki Asli, K.R. Williams, P.L. Lai, X. Wang, R. Montazami, and N.N. **Hashemi**, “Viability of Neural Cells on 3D Printed Graphene Bioelectronics”, *Biosensors*, 9(4):112, 2019. https://doi.org/10.3390/bios9040112
- Heylmun, J. C., B. Kong, A. **Passalacqua**, and R. O. **Fox**, “A Quadrature-Based Moment Method for Polydisperse Bubbly Flows,” *Computer Physics Communications* 244:187-204, 2019.
- Li, D., Bothell, J.K., Morgan, T.B., Machicoane, N., Aliseda, A., Kastengren, A.L., and **Heindel**, T.J., “Time-Averaged Spray Analysis in the Near-Field Using X-ray Measurements,” *Atomization and Sprays*, 29(4): 331-349, 2019. DOI: 10.1615/AtomizSpr.2019030744
- Li, LK, Y. Liu, and H. **Hu**. "An Experimental Study on Dynamic Ice Accretion Process over the Surfaces of Rotating Aero-Engine Spinners". *Experimental Thermal and Fluid Science*, 109: 109879 (13 pages). 2019. https://doi.org/10.1016/j.expthermflusci.2019.109879
- Liu, Y., C. Kolbakir, H.Y. Hu, X.S. Meng, and H. **Hu**. "An Experimental Study on the Thermal Effects of Duty-Cycled Plasma Actuation Pertinent to Aircraft Icing Mitigation”, *International Journal of Heat and Mass Transfer, 136:864-876, 2019.* https://doi.org/10.1016/j.ijheatmasstransfer.2019.03.068
- Liu, Y., W.L. Chen, Y.H. Peng, and H. **Hu**. "An Experimental Study on the Dynamic Ice Accretion Processes on Bridge Cables with Different Surface Modifications", *Journal of Wind Engineering & Industrial Aerodynamics*, 190:218-229, 2019. https://doi.org/10.1016/j.jweia.2019.05.007

- Liu, Y., Z.C. Zhang, H.Y. Hu, A. Samanta, Q.H. Wang, H.T. Ding and H. **Hu**."An Experimental Study to Characterize a Surface Treated with a Novel Laser Surface Texturing Technique: Water Repellency and Reduced Ice Adhesion", *Surface and Coatings Technology*,374:634-644, 2019. https://doi.org/10.1016/j.surfcoat.2019.06.046
- McNamara, M.C., R.J. Pretzer, R. Montazami, and N.N. **Hashemi**, "Shear at Fluid-Fluid Interfaces Affects the Surface Topologies of Alginate Microfibers", *Clean Technologies*, 1, 265-272, 2019.
- Peng, C., B. Kong, J. Zhou, B. Sun, A. **Passalacqua**, S. **Subramaniam**, and R. O. **Fox**, "Implementation of Pseudo-Turbulence Closures in an Eulerian-Eulerian Two-Fluid Model for Non-Isothermal Gas-Solid Flow," *Chemical Engineering Science* 207, 663-671, 2019.
- R.L. Pemathilaka, R.L., D.E. Reynolds, and N.N. **Hashemi**, "Drug Transport across the Human Placenta: Review of Placenta-on-a-Chip and Previous Approaches", *Interface Focus*, 9, 20190031, 2019.
- Sharifi, F., B.B. Patel, M.C. McNamara, P. Meis, M. Roghair, M. Lu, R. Montazami, D.S. Sakaguchi, and N.N. **Hashemi**, "Photo-Cross-Linked Poly(ethylene glycol) Diacrylate Hydrogels: Spherical Microparticles to Bow Tie-Shaped Microfibers", *ACS Applied Materials & Interfaces*, 11:18797-18807, 2019.
- Wang, X.D., Z.L. Ye, S. Kang, and H. **Hu.** "Investigations on the Unsteady Aerodynamic Characteristics of a Horizontal-Axis Wind Turbine during Dynamic Yaw Processes", *Energies*, 12:3124, 2019. https://doi.org/10.3390/en12163124
- Wrede, A.H., F. Al-Masri, R. Montazami, and N.N. **Hashemi**, "Investigation of Cavitation-Induced Damage on PDMS Films", *Analytical Methods*, 2019. https://doi.org/10.1039/C9AY01576K
- Yeh, H.-L., and **Juárez**, J.J. " Oil Phase Displacement by Acoustic Streaming in a Reservoir-on-a Chip", *Microfluidics and Nanofluidics*, 23:113, 2019. https://doi.org/10.1007/s10404-019-2279-x
- Zheng, K., W. Tian, J. Qian, S.L. Zhang and H. **Hu**. "Effect of Film Cooling Injection on Aerodynamic Performances of Scramjet Isolator", *Aerospace Science and Technology*, 2019. https://doi.org/10.1016/j.ast.2019.105383

Recent Conference Publications

- **Heindel**, T.J., Morgan, T.B., Burtnett, T.J, Bothell, J.K., Li, D., Aliseda, A., and Machicoane, N., “High-Speed Flow Visualization of a Canonical Airblast Atomizer Using Synchrotron X-rays,” *AJK2019 – Joint ASME/JSME/KSME Fluids Engineering Division Summer Meeting*, July 28 – August 1, 2019, San Francisco, CA, Paper Number: AJKFLUIDS2019-4992.
- Montilla, C., Y. Nasro-Allah, R. Ansart, R. O. **Fox**, and O. Simonin, “Eulerian Modeling of Monodisperse Gas-Particle Flow with Electrostatic Forces,” in *Proceedings of 10th International Conference on Multiphase Flow (ICMF 2019)*, Rio de Janeiro, Brazil, pp. 1-9, 2019.
- Pillers, R.A., Morgan, T.B., **Heindel**, T.J., and Estanga, D. “X-ray Flow Visualization of Cyclopentane Hydrate Formation,” *AJK2019 – Joint ASME/JSME/KSME Fluids Engineering Division Summer Meeting*, July 28 – August 1, 2019, San Francisco, CA, Paper Number: AJKFLUIDS2019-5091

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