IOWA STATE UNIVERSITY
Center for Multiphase Flow Research and Education

CoMFRE March 2019 Newsletter

Welcome to the first quarterly CoMFRE Newsletter. We hope you find the information summarized below of value. Please let us know if you would like us to add any additional content.

New CoMFRE Director

In September 2018, Arun Somani, Associate Dean for Research in the College of Engineering, announced that Ted **Heindel** accepted the director position of CoMFRE. Somani thanked Shankar **Subramaniam**, the first Director of CoMFRE, for his leadership in forming the center and for taking it through the approval process. Because of Subramaniam's leadership, CoMFRE is in a strong position to advance multiphase flow research and education.

Message from the Director

I would like to welcome everyone to the first CoMFRE newsletter. Our goal is to provide CoMFRE updates to member companies, affiliates, and supporters on a quarterly basis. The newsletter will include CoMFRE news items from the last quarter, a list of recent federal research grants, and a list of recent multiphase flow related publications from CoMFRE affiliates. A summary of CoMFRE faculty research activities will also appear periodically. Since this newsletter is for you, please let me know if you would like to see other features introduced.

With kind regards,

Ted

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

Save the Date!

Please mark your calendar for the CoMFRE membership meeting on **October 28-29, 2019** in Ames, IA. Details will be forthcoming, but plan for the meeting to start the evening of October 28 with a dinner and end on October 29 by 4 pm.

Membership News

CoMFRE has grown to three members with the addition of BASF in January 2019. The other two current members are AbbVie and BP. We value the input from our current members and continue to look for ways to

engage these companies in our research and education activities. We will also continue to grow our membership as opportunities arise.

New CoMFRE Program Coordinator

CoMFRE welcomes our new program coordinator, Janice (Jan) **Seibel**. Jan began with CoMFRE on January 1, 2019. She came from the Center for Arthropod Management Technologies (CAMTech). Jan's duties include coordinating day-to-day CoMFRE activities, CoMFRE communications, CoMFRE metric tracking, proposal submission assistance, and CoMFRE account tracking. She is excited to learn about the many areas where multiphase flows are found.

CoMFRE seminar April 10: David Green

We are pleased to host David Green, University of Virginia Professor of Materials Science and Chemical Engineering, who will give a seminar on Wednesday, April 10: "Nanoparticle Stability and Dynamics in Polymer Matrices". See more.

CoMFRE and CoMFRE Affiliates in the News

- **CoMFRE off to a great start:** After a long start-up process, and with help from the Engineering Research Institute's Accelerating Collaboration in Research Initiative (ACRI), CoMFRE is making an impact: https://news.engineering.iastate.edu/2019/03/21/comfre-coes-newest-center/.

- **CoMFRE Overview to College of Engineering:** On March 26, CoMFRE Director Ted **Heindel** provided an overview to the College of Engineering Dean Sarah Rajala and Associate Dean for Research Arun Somani. The 15-minute presentation provided a summary of CoMFRE accomplishments for the past year and goals for the coming year. The complete presentation can be found here: https://iastate.box.com/s/m9oxtauobz2x3xw2nwgd9g9uhaegrhll.

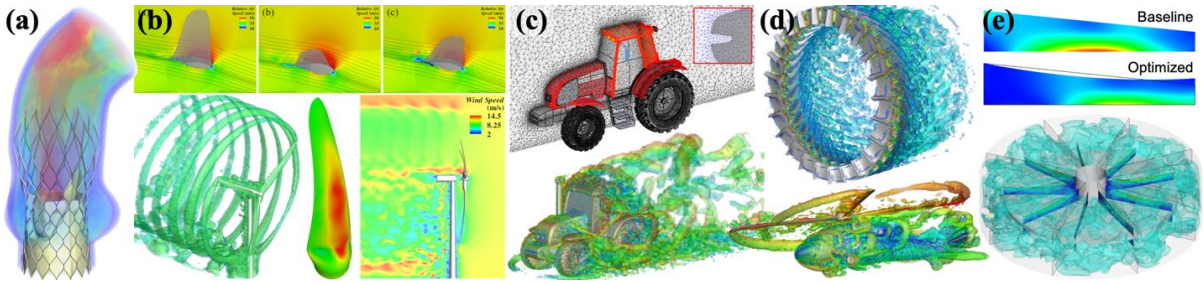
- **Engineers develop placenta-on-a-chip to study caffeine transport from mother to fetus:** Associate professor Nicole **Hashemi** has used her expertise in microfluidics to lead development of a device that models a human placenta. The model will be used to study the transport of various constituents between a mother and her fetus. The first study addresses caffeine transport. More information can be found at https://www.news.iastate.edu/news/2019/02/18/placenta-on-a-chip.

- **Iowa State, U of Ottawa collaboration examines electrostatic charging of particles in insulating materials:** Associate professor Alberto **Passalacqua** leads an ISU collaboration with the University of Ottawa in Canada to examine electrostatic charging of particles made of insulating materials such as plastic in fluidized bed reactors. The findings of this research can be applied to industries in Iowa (as well as Canada and other parts of the world), advancing Iowa State's mission as a land-grant university. Specifically, this research can be applied to systems where particles can accumulate charge due to impact, leading to operational difficulties and safety hazards. The full story can be found at https://news.engineering.iastate.edu/2018/11/29/iowa-state-u-of-ottawa-collaboration-examines-electrostatic-charging-of-particles-in-insulating-materials/.

- **Passalacqua presents seminar series on quadrature-based moment methods:** Associate professor Alberto **Passalacqua** developed a 3-part seminar series for ISU graduate students focused on the fundamental aspects at the root of quadrature-based moment methods. Quadrature-based moment methods are a framework that allows the formulation of closures for the evolution equations of a distribution function (DF). They have been applied to the solution of various forms of integro-differential equations whose unknown is a DF. Notable examples are the Boltzmann-Enskog equations for gas dynamics, the Williams equation for sprays, and the generalized population balance equation used to describe the evolution in space and time of a distribution of particles whose particle properties (size, composition, etc.) may change in space and time. The concept of moment of a distribution function was introduced in part 1. The framework to formulate quadrature-based closures of moment equations with univariate and multivariate DFs was illustrated using various multiphase flow examples in part 2. Finally, the requirements for a numerical scheme to be used with moment methods was presented in part 3.

CoMFRE Research Review – Assistant Professor Ming-Chen Hsu

Dr. Hsu's research interests lie in the field of **Computational Fluid–Structure Interaction (FSI)** with particular emphasis on developing novel numerical methods for solving real-world problems. His research team has been focusing on developing a verified and validated modeling and simulation paradigm named **Immersogeometric Analysis** that integrates complex geometric design, multiphysics analysis, and optimization. The immersogeometric framework provides effective use of computational FSI and high-fidelity multiphysics analysis for gaining a high degree of knowledge about the design space and tradeoffs. It has since been applied to various multiphase flow, engineering, and science applications, including (a) improving **artificial heart valve** performance and durability, (b) understanding **wind turbine** rotor–tower interaction, (c) studying **turbulent flow** around complex geometries, (d) optimizing **gas turbine** off-design efficiency, and (e) solving **hydraulic arresting gear** fatigue issues. Visit Hsu's web site for more information: https://web.me.iastate.edu/jmchsu.



Recently Received Federal Grants for CoMFRE Affiliated Faculty

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

- "Three Dimensional Printed Scaffolds for Understanding Effect of Cavitation on Blood Brain Barrier" PI – Nicole **Hashemi**; Funding Agency – Office of Naval Research; New funding amount - $100,000.
- "X-ray Imaging of Multiphase Flows of Interest to ONR" PI – Theodore **Heindel**; Funding Agency – Office of Naval Research; New funding amount - $50,000.
- "Biomechanical Indicators of Bicuspid Aortic Valve Dysfunction" PIs – Michael S. Sacks (UT Austin), Ming-Chen **Hsu** (ISU), Robert Gorman (UPenn); co-PIs – Alison Pouch (UPenn), Walter Witschey (UPenn), Giovanni Ferrari (Columbia); Funding Agency – NIH (R01HL142504); New funding amount - $2,940,862 ($400,000 to Hsu).
- "CAREER: Multifidelity Modeling and Search using Adaptive Field Prediction" PI – Leifur **Leifsson**; Funding Agency – National Science Foundation ; New funding amount – $500,000; https://www.nsf.gov/awardsearch/showAward?AWD_ID=1846862&HistoricalAwards=false.

- “CAREER: Robustifying Machine Learning for Cyber-Physical Systems” PI – Soumik **Sarkar**; Funding Agency – National Science Foundation; New Funding Amount - $97,460; https://www.nsf.gov/awardsearch/showAward?AWD_ID=1845969&HistoricalAwards=false.
- “Microwave Enhancement of Composite Solid Propellant Flames” PI – Travis **Sippel**; Funding Agency – Air Force Office of Scientific Research; New funding amount - $120,665.

Recent Journal Publications

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

- Barkley, S.J., Zhu, K., Lynch, J.E., **Michael**, J.B., **Sippel**, T.R., “Microwave plasma enhancement of multiphase flames: On-demand control of solid-propellant burning rate,” *Combustion and Flame.* 199: 14-23, 2019.
- Bingol, O, **Krishnamurthy**, A., “NURBS-Python: An open-source object-oriented NURBS modeling framework in Python,” *SoftwareX*. 9: 85-94, 2019.
- Chen, X., Zhong, W., and **Heindel**, T.J., “Using stereo XPTV to determine cylindrical particle distribution and velocity in a binary fluidized bed,” *AIChE Journal*. 65:2 520-535, 2019. https://doi.org/10.1002/aic.16485.
- Dou, Q., **Shrotriya**, P., Li, W., Hebert, K.R., “Stress-generating electrochemical reactions during the initial growth of anodic titanium dioxide nanotube layers,” *Electrochimica Acta*. 295: 418-426, 2019.
- **Heindel**, T.J., “X-ray imaging techniques to quantify spray characteristics in the near field,” *Atomization and Sprays*. 28:11 1029-1059, 2018. DOI: 10.1615/AtomizSpr.2019028797.
- Herrema, A.J., Johnson, E.L., Proserpio, D., Kiendl, J., **Hsu**, M.-C., “Penalty coupling of non-matching isogeometric Kirchhoff–Love shell patches with application to composite wind turbine blades,” *Computer Methods in Applied Mechanics and Engineering*. 346: 810–840, 2019. https://doi.org/10.1016/j.cma.2018.08.038.
- Herrema, A.J., Kiendl, J., **Hsu**, M.-C., “A framework for isogeometric analysis-based design and optimization of wind turbine blade structures,” *Wind Energy*. 22: 153–170, 2019. https://doi.org/10.1002/we.2276.
- Huston M.R., **Sippel**, T.R., “Confined flame propagation of Al/PTFE mechanically activated composites,” *Combustion and Flame*. 203: 83-91, 2019.
- Liu, Z., Hill, J.C., **Fox**, R.O., **Passalacqua**, A., Olsen M.G., “A delayed detached eddy simulation model with low Reynolds number correction for transitional swirling flow in a multi-inlet vortex nanoprecipitation reactor,” *Chemical Engineering Science*. 193: 66–75, 2019. doi:10.1016/j.ces.2018.08.020.
- Ray, M., Chowdhury, F., Sowinski A., Mehrani, P., **Passalacqua**, A., “An Euler-Euler model for mono-dispersed gas-particle flows incorporating electrostatic charging due to particle-wall and particle-particle collisions,” *Chemical Engineering Science*. 197: 327–344, 2019. doi:10.1016/j.ces.2018.12.028.
- White, A.R., **Ward**, T., “Surface remobilization of buoyancy-drive surfactant-laden drops at low Reynolds and capillary numbers,” *AIChE Journal*. 65:1 294-304, 2019.
- Wu, M.C.H., Zakerzadeh, R., Kamensky, D., Kiendl, J., Sacks, M.S., **Hsu**, M.-C., “An anisotropic constitutive model for immersogeometric fluid–structure interaction analysis of bioprosthetic heart valve,” *Journal of Biomechanics*. 74: 23–31, 2018. https://doi.org/10.1016/j.jbiomech.2018.04.012.
- Xu, F., Bazilevs, Y., **Hsu**, M.-C., Immersogeometric analysis of compressible flows with application to aerodynamic simulation of rotorcraft. *Mathematical Models and Methods in Applied Sciences*. Accepted; 2019. https://doi.org/10.1142/S0218202519410033.
- Xu, F., Morganti, S., Zakerzadeh, R., Kamensky, D., Auricchio, F., Reali, A,. Hughes, T.J.R., Sacks, M.S., **Hsu**, M.-C., “A framework for designing patient-specific bioprosthetic heart valves using immersogeometric fluid–structure interaction analysis,” *International Journal for Numerical Methods in Biomedical Engineering*. 34: e2938, 2018. https://doi.org/10.1002/cnm.2938.
- Yu, Y., Kamensk,y D., **Hsu**, M.-C., Lu, X.Y., Bazilevs, Y., Hughes, T.J.R., “Error estimates for dynamic augmented Lagrangian boundary condition enforcement, with application to

immersogeometric fluid–structure interaction," *Mathematical Models and Methods in Applied Sciences*. 28: 2457–2509, 2018. https://doi.org/10.1142/S0218202518500537.

The CoMFRE Newsletter is published quarterly. The next issue will be published June 30.

If you have questions or news items to suggest, please contact CoMFRE at comfre@iastate.edu
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