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2024 Newsletter — Scientific Computing and Flow Physics Laboratory

SCFPL this Year

PhD Students:	Ellie Anderson-Zych, Erin Burrell, Sonya Dick, Codie Fiedler-Kawaguchi (co-advised by Xun Huan), Baudouin Fonkwa, Bjorn Kierulf, Nick Lucido (advised by S. Ceccio), Madeline Marusich, Curtis Maxon (co-advised by Karthik Duraisamy), William White
MS Students:	Xinyu Xie, Haylea Bazinau
UG Students:	Chenhao Zhu, Jessie Qiu, Tony Janette, Sunaad Gurajada
Post-docs:	Ziyang Huang, Stephen DiIorio
Admin:	Diane Brouwer
PI:	Eric Johnsen

Research Highlights

Our group members have worked on problems across a variety of fields this year:

- *Multiphase flows*:
  - We are extending our models for cavitation in soft matter to predict traumatic brain injury due to blasts and directed energy.
  - We are investigating potential damage by high-speed droplet impact to solid surfaces in the context of hypersonics.
  - We are conducting fundamental studies of oblique shock-interface interactions.
- *High-energy-density physics*:
  - We are investigating vortex rings ejected from shocked interfaces and their stability, including under the effect of magnetic fields and as they apply to supernovae.
  - We are developing models to study photoionization fronts.
  - We are using interfacial perturbations to determine material properties at high pressures in the context of planetary formation.
- *Scientific Computing*:
  - We are developing Discontinuous Galerkin methods with adaptive mesh refinement for massively parallel, high-resolution simulations of the compressible multiphase Navier-Stokes equations.
  - We are developing Phase-Field models to improve the accuracy of the representation of material interfaces.
  - We are investigating numerical errors at mesh boundaries in the context of hp adaptive methods.
  - We are developing numerical methods for fully coupled compressible fluid/solid problems.
  - We are applying optimal experimental design to material characterization in shocked systems.

This year, articles with contributions from our group appeared in Physical Review Letters, the Journal of Computational Physics, the Journal of Fluid Mechanics, Physics of Plasmas, and the AIAA Journal:

- A hydrodynamic mechanism for clumping along the equatorial rings of SN1987A and other stars
- A consistent and conservative Phase-Field method for compressible N-phase flows: Consistent Limiter and Multiphase Reduction-Consistent Formulation
- Feasibility of an experiment on clumping induced by the Crow instability along a shocked cylinder

- Stability of a pair of vortex rings
- Large-eddy simulations of flow over a backward-facing ramp with a wall-mounted cube

The group had good representation at the APS-DPP and APS-DFD meetings, and also presented at the International Conference on Numerical Methods for Multiphase Flows, the International Symposium on Cavitation, the International Workshop on the Physics of Compressible Turbulence and Mixing, AIAA SCITECH. We also participated in the PANTHER workshop in Madison.

We started one new project this year:

> Algorithm/Software/Hardware Co-design for High Energy Density applications (LANL, Karthik Duraisamy PI)

We take this opportunity to acknowledge the invaluable contributions from our research collaborators this past year: C. Franck and Alice Fawzi (Wisconsin), R. Carlsen (Robert Morris U.), J. Wicks (Johns Hopkins U.), B. Perfect, H. Beydoun, R. Smith, P. Celliers (LLNL), E. Merritt, A. Rasmus, J. Dolence (LANL), X. Huan, H. LeFevre, C. Kuranz, K. Duraisamy, K. Maki, A. Towne (U-M), as well as former group members S. Tandon (AMD), Y. Elmore (Stanford), and M. Balakrishnan (Ichor Systems). We are also grateful to our sponsors for their support: ONR, DOE/NNSA, and LANL, as well as OLCF and ACCESS for computing resources.

Group Happenings this Year

Welcome to this year's new members to the group:

- Graduate students Haylea Bazinau, Madeline Marusich, Curtis Maxon
- Undergraduates Tony Janette and Sunaad Gurajada
- Postdoc Stephen DiIorio

Congratulations to Sonya Dick on defending her PhD! Sonya started as Assistant Professor at South Dakota School of Mines and Technology, Ziyang as Assistant Professor at the University of Alabama, Kevin as postdoc at LANL. Jessie is now a graduate student at Stanford.

Eric rotated off his position as Associate Chair for Undergraduate Education and took on the position of Director of the PhD Program in Scientific Computing.

Congratulations to group members:

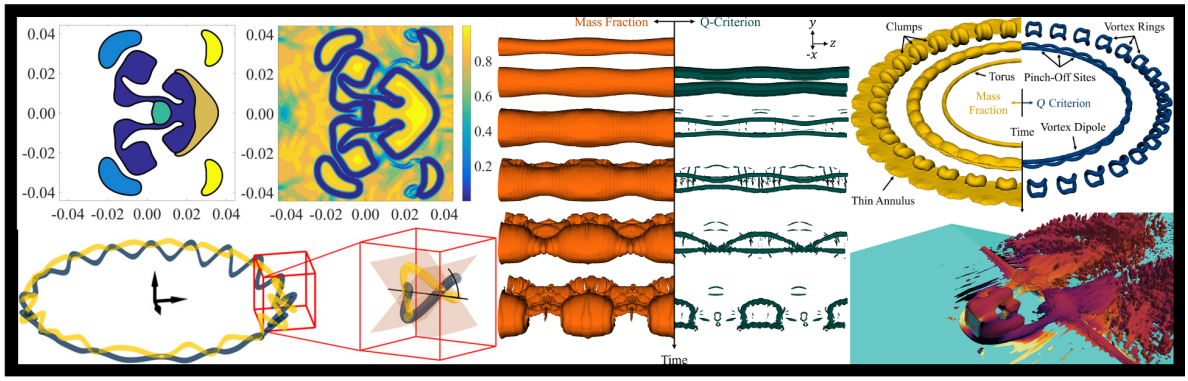
- Sonya Dick, Poster award (NIF/JLF User Group Meeting, LLNL)
- Sunaad Gurajada: Best paper award (ME Undergraduate Symposium, U-M)
- Michael Wadas, Poster award (Omega User Group meeting, Laboratory for Laser Energetics)

Alumni News:

- Shaowu Pan (RPI) received a major DOE grant for AI for scientific research.
- Brandon Patterson (APL) was recognized with the Mission Accomplishment Award for an Emerging Challenge (in 2023—sorry for the late notice)

- Several former group members have taken on leadership positions within their respective departments (Seth Norberg, Eunhye An)

Apologies if we missed some of our alumni's achievements—please let us know if this is the case. And do stay in touch, we want to hear about you!



Selected artwork from this year's SCFPL papers
(Z. Huang, M. Wadas, S. Tandon)

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