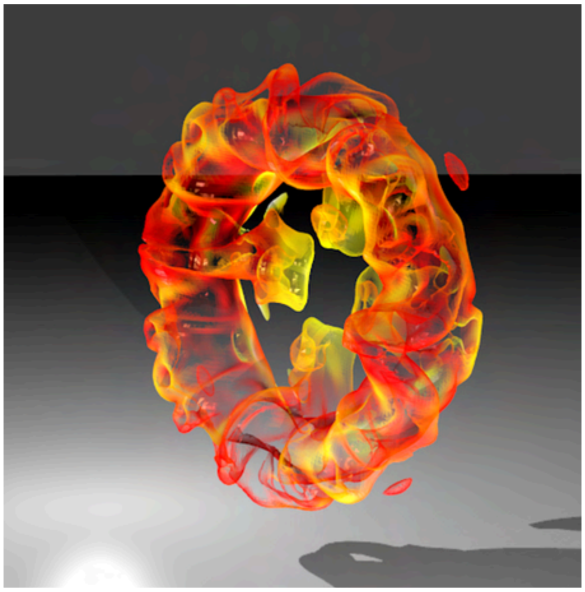
MICDE Welcomes Eric Johnsen as the New Director for the PhD in Scientific Computing Program

Eric Johnsen
Professor,
Mechanical Engineering

The Michigan Institute for Computational Discovery and Engineering (MICDE) has appointed Eric Johnsen as the new program director for the PhD in Scientific Computing program.

As part of a joint degree program, Johnsen will guide students from an array of disciplines. The program currently includes students from nine different schools and colleges with departments ranging from physics and chemistry to political science and aerospace and mechanical engineering.

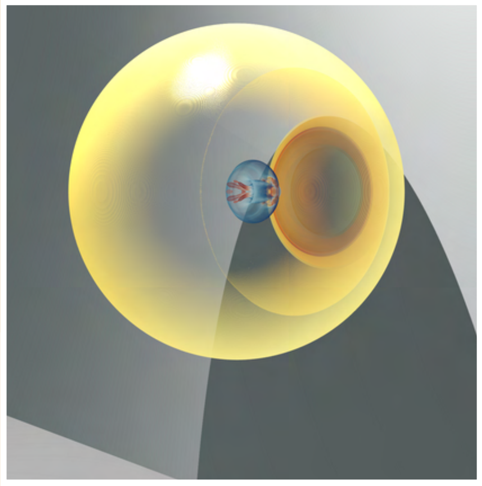
"I am excited to direct the PhD in Scientific Computing program," said Johnsen. "The essence of computational discovery lies in equipping our students with a fundamental understanding of numerical methods so they can make informed decisions about which computational tools to use to progress their research. My aim is to ensure our program not only keeps pace with, but also anticipates the evolving demands of scientific progress across disciplines."



Vortex ring following the collapse of a gas bubble near a solid object visualized using the Q criterion and colored by temperature. [credit: S. A. Beig]

A professor of mechanical engineering and former associate chair for undergraduate education in the College of Engineering, Johnsen has been an integral member of the MICDE community for over a decade. His research focuses on advancing the field of fluid mechanics by addressing challenges to computational fluid dynamics, multiphase flows, high-speed flow phenomena, turbulence and interfacial instabilities. Johnsen's expertise also extends to high-performance computing targeting novel paradigms, such as variable-precision computing, multi-GPU parallelism and algorithms for large-scale computations. Understanding these basic flow phenomena is key for addressing societal challenges in the energy sciences, medicine, national security and astrophysics.

“Diversity of thought and discipline is an integral part of our work,” Johnsen observes. “In recent years, nearly all my PhD students have enjoyed a close collaboration with an experimental group. In addition to grounding our research in the real world, these collaborations have enabled advances that no single investigator could have made on their own.”



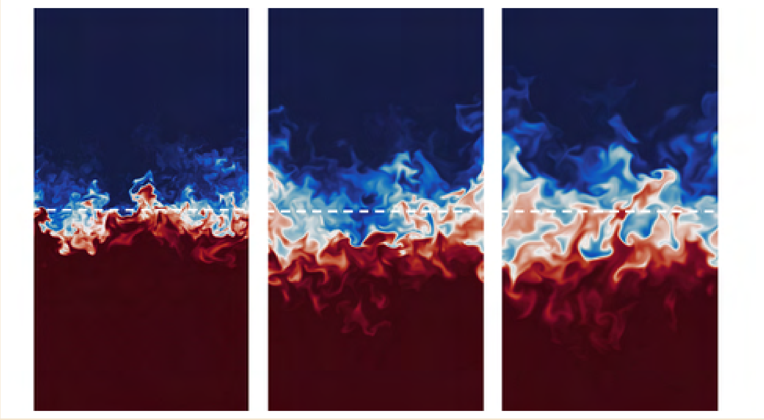
Non-spherical collapse of a gas bubble and the shock wave thereby produced near a solid object visualized using the volume fraction and pressure isosurfaces. [credit: S. A. Beig]

Focused on developing high-order accurate numerical methods for partial differential equations, Johnsen and his students use large-scale simulations at leadership-class computing facilities as numerical experiments, combining them with theory to dissect fundamental aspects of flow physics, such as cavitation-bubble dynamics, hydrodynamic instabilities, vortex rings and turbulent mixing.

“While my group’s day-to-day research lies between applied mathematics and applied physics, what we truly care about as computational engineers is solving real problems and making a positive impact on society,” Johnsen said.

With collaborators at Robert Morris University and the University of Wisconsin, Johnsen and his students are leveraging their expertise in numerical modeling of bubble dynamics in soft matter to understand the basic mechanisms of blast-induced traumatic brain injury, a challenge currently receiving significant attention across the nation.

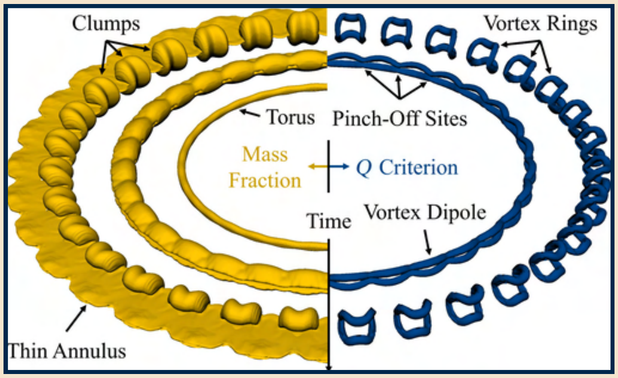
“Particularly in cases where there is no externally visible injury signature, our collaborative work suggests that neuronal injury mechanisms due to a single, relatively high-amplitude blast or repeated lower-grade exposures may be the same, and cavitation may be a central element to this problem,” Johnsen said. “This knowledge is critical to the development of safety metrics and protective strategies. It is especially satisfying to see the fruit of our theoretical studies being used in practice to help others.”



Time evolution of turbulent mixing between high- and low-intensity turbulence visualized using mass fraction contours. [credit: E. An]

In close collaboration with Carolyn Kuranz, associate professor of nuclear engineering and radiological sciences, Johnsen's group studies basic flow physics under extreme conditions. These conditions can be found in stars or generated in inertial confinement fusion, which may eventually lead to a reliable, clean, safe and abundant source of energy.

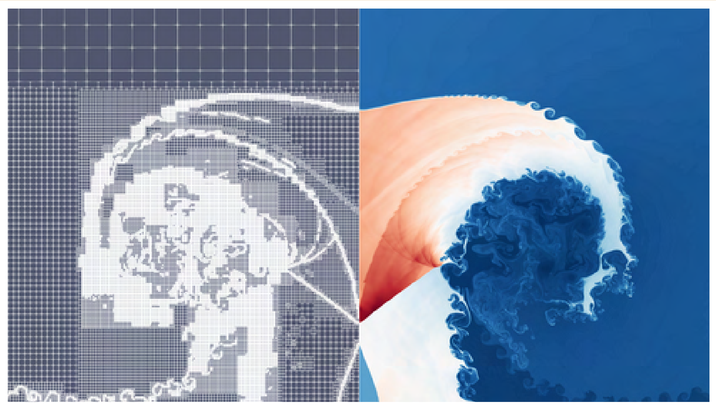
"It is exciting to be able to help infer properties of materials under previously unattainable pressures or contribute to understanding what happens when stars die with our computational tools," Johnsen notes.



Predicted evolution of an initially expanding torus into discrete hot spots for Supernova 1987A visualized by mass fraction and Q-criterion isosurfaces. [credit: M. J. Wadas]

Johnsen's research has been supported by the U.S. Department of Energy, National Nuclear Security Administration, Office of Naval Research, National Institutes of Health, National Science Foundation and various national laboratories and companies.

Established in 1988 as the first of its kind, the University of Michigan's PhD in Scientific Computing program emerged in response to the growing recognition of computational science as a crucial complement to theory and experimental methods. The program has met the increasing demand for advanced computational skills across a spectrum of disciplines, exemplifying U-M's pioneering leadership in this field. With alumni working across a range of sectors, from academia to industry and national laboratories, the diverse applications of their broad computational science skills underscore the impact and success of the MICDE program.



Shock wave interaction with a triple point in gases visualized using the (adaptive) mesh and density. [credit: W. J. White]

The program expanded significantly when it was integrated into MICDE in 2013. It now embodies the university's commitment to interdisciplinary research, offering comprehensive training and fostering innovative computational approaches to complex scientific inquiries.

Over the years, the program has seen its impact amplified by notable initiatives such as the MICDE Fellows, which honors outstanding students for their exceptional academic and research potential. Events like the Advanced Scientific Computing and Engineering Showcase and Women in

Computational Science Symposium have enriched the academic experience for students and faculty and highlighted the significant contributions of diverse voices in the computational science community.

Throughout his career, Johnsen has advised over 30 PhD students. The alumni he has worked with are evenly divided between academics, national lab scientists and industry researchers. He also has worked closely with over 80 graduate and undergraduate student researchers.

“I find great pleasure in working with students, particularly on research,” Johnsen said. “I’ve been fortunate to be able to recruit an exceptional group of students who are not only excellent researchers, but are also outstanding people. It is a special treat to see the great things they accomplish after they leave, particularly in areas far removed from their research in the group.”

During his term as associate chair for undergraduate education in mechanical engineering, Johnsen spearheaded several key initiatives. He helped launch a concentration in robotics, enhanced Research, Innovation, Service and Entrepreneurship (RISE) activities for undergraduates, developed professional development opportunities for lecturers and worked to identify and address diversity, equity and inclusion challenges faced by incoming undergraduates.

“MICDE is delighted to welcome Eric Johnsen as the new program director for the PhD in Scientific Computing program,” said Karthik Duraisamy, MICDE director. “He brings strong research expertise and a fresh perspective on computational science education and has a number of innovative ideas and curriculum advancements that will enrich the experience of MICDE students and better prepare them for their future careers.”

Johnsen earned a BS in 2001 from the University of California, Santa Barbara. In 2002, he received an MS followed by a PhD in 2008, both from the California Institute of Technology (Caltech). Johnsen conducted a postdoctoral fellowship at the Center for Turbulence Research at Stanford University from 2007 to 2009. He has been at U-M since 2010.

Recognized with the CAREER Award from the National Science Foundation in 2013, the Young Investigator Award from the Office of Naval Research in 2012 and the Ralph E. Powe Junior Faculty Enhancement Award in 2010, Johnsen’s accolades speak to his influence and excellence.