AAE SPRING COLLOQUIUM SERIES

Advancing Predictive Technologies for High-Speed Propulsion with Accelerated Scale Resolving Computations

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Abstract:

This seminar outlines progress in predictive modeling of chemically reacting flows in high-speed propulsion systems. At high speeds, fluid-dynamic and chemical time scales are tightly coupled, and experiments are often too costly for iterative design. Computation is therefore essential, yet existing reduced-order models do not extend naturally to these regimes, making scale-resolving simulations necessary to capture the underlying physics. My work develops accelerated numerical methods for systems such as dual-mode ramjets and detonation engines that require robust, scalable modeling of shocks, turbulence, and chemistry. A central focus is the development of structure-preserving, conservative formulations for unstructured grids, paired with chemistry-acceleration tools for modern high-performance computing architectures. In parallel, my research integrates reduced-order and network-based compression strategies to accelerate simulations and reduce computational cost. Together, these efforts will be essential to build a unified framework for simulating complex propulsion environments and advance next-generation high-speed transport.

Biography

Dr. Ryan F. Johnson is a senior scientist from the US Naval Research Laboratory in Washington, DC specializing in propulsion modeling utilizing various computational techniques. He was recently on sabbatical as a visiting scholar at Stanford University in Professor Hai Wang's group, focusing on the intersection of high-performance computing, computational fluid dynamics (CFD), and chemical kinetics. Born and raised in central Virginia, he earned his Ph.D. from the University of Virginia in 2014, where he studied under Professor Harsha Chelliah. Since completing his doctorate, Dr. Johnson has joined the U.S. Navy's Laboratories for Computational Physics and Fluid Dynamics, leading several high-speed propulsion initiatives. His expertise spans propulsion, CFD, complex physics, methods in solving nonlinear systems, embedded machine learning, and technology transition. His work emphasizes scalability and robustness, enabling highly accurate predictions in complex geometries with intricate physics. Through his research, he continues to develop and apply advanced numerical methods to improve propulsion modeling and leverage high-performance computing. Dr. Johnson is a recent recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE), as conferred by the United States government and signed by President Joseph R. Biden.

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