UNIVERSITY OF MARYLAND

THE BURGERS PROGRAM FOR FLUID DYNAMICS
THE FLUID DYNAMICS REVIEWS SEMINAR SERIES

AN OPTIMIZATION-BASED FORMULATION FOR AUTOMATED HYPERSONIC FLOW SIMULATIONS AND HIGH-ORDER METHODS FOR HIGH-SPEED PROPULSION

Thursday, April 30, 2026 | 3 pm
Mechanical Engineering Seminar Room
2164 Glenn L. Martin Hall

Speaker

DR. ANDREW D. KERCHER

Research Mathematician
US Naval Research Laboratory, Washington, D.C.

ABSTRACT

Accurate numerical simulations of external hypersonic flows and high-speed air-breathing propulsion systems present fundamental challenges, primarily due to the complex interaction between discretization errors, grid quality, strong shock waves, and disparate scales, both spatial and temporal. Grid generation is a major bottleneck in simulations of vehicles undergoing hypersonic flight because it requires significant manual intervention to align mesh interfaces with shock surfaces and provide adequate resolution within the boundary layer in the wall-normal direction; failure to do so often leads to spurious numerical artifacts and nonphysical heating anomalies. The Moving Discontinuous Galerkin Method with Interface Condition Enforcement (MDG-ICE) is an optimization-based, r-adaptive formulation that treats both the computational grid and the flow field as solution variables. In doing so, this approach overcomes traditional bottlenecks by automatically repositioning grid points to both align grid interfaces with discontinuous flow features and resolve sharp, but smooth, gradients. Not only does this method improve workflow automation by automating shock alignment and boundary layer grid generation, but it also produces highly accurate solutions without the need for artificial stabilization. To address the accurate prediction of flow physics in high-speed air-breathing propulsion systems, where finite-rate chemistry and multicomponent species transport must be resolved at the small spatial and temporal scales characteristic of scramjet combustion environments, a fully conservative, positivity-preserving, and entropy-bounded discontinuous Galerkin scheme for the chemically reacting, compressible Navier-Stokes equations is presented. This scheme guarantees the positivity of species concentrations, density, and pressure, thereby preventing a common cause of catastrophic simulation failure. Taken together, the optimization-based, high-order, r-adaptive formulation and the structure-preserving high-order scheme represent complementary advances toward automated and reliable, high-fidelity simulations of the fully coupled hypersonic flight and propulsion environment.

BIO

Dr. Andrew D. Kercher is a Research Mathematician at the U.S. Naval Research Laboratory (NRL) in Washington, DC. With a background in Numerical Analysis and Computational Fluid Dynamics (CFD), he brings 11 years of experience developing advanced, performance-portable modeling and simulation capabilities. His current research focuses on high-speed aerodynamics, propulsion systems, and shock-dominated flows. At NRL, his work directly supports and accelerates the design cycle for high-speed aerospace vehicles through the advancement of high-fidelity computational methods that address the fundamental challenges of predicting the aerothermochemical environment during hypersonic flight.

UNIVERSITY OF MARYLAND 1856
A. JAMES CLARK
SCHOOL OF ENGINEERING