

NEW TRENDS FOR THE NUMERICAL SOLUTION OF HYPERBOLIC SYSTEMS IN COMPRESSIBLE FLUID FLOWS

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ABSTRACT

Nonlinear hyperbolic balance laws serve as the mathematical foundation for a vast range of fluid dynamic processes. Despite their widespread use, addressing fundamental hyperbolic phenomena, such as the complex multi-scale interaction of shock waves with shear instabilities, or the coupling of hyperbolic transport with stochastic environments, remains a challenge for numerical modeling. A prominent example is the inadequacy of the classical entropy principle to guarantee unique solutions in multidimensional systems, often giving rise to highly oscillatory, non-unique flow fields.

Consequently, this minisymposium aims to explore recent breakthroughs and novel directions in the design of tailored, robust numerical frameworks for hyperbolic balance laws. We welcome contributions focusing on innovative solution concepts, multi-scale methodologies, and computational approaches for probabilistic fluid dynamics. This scope encompasses high-resolution and high-order discretizations exploiting generalized entropy formulations, dissipative limits, or advanced approaches for non-local and multi-scale problems, such as subgrid-scale modeling within continuum frameworks. Furthermore, emphasis is placed on structure-preserving and stable schemes, including recent advances in entropy-conservative or entropy-stable methods, well-balancing, and the accurate capturing of asymptotic states like low-Mach limits. Finally, the session targets uncertainty quantification and algorithmic

developments for stochastic hyperbolic systems, featuring probabilistic formulations for statistical turbulence via stochastic variational principles or hybrid data-driven and filtering techniques.

This session serves as a collaborative platform highlighting ongoing research from the German Priority Research Program SPP-2410 ("Hyperbolic Balance Laws in Fluid Mechanics: Complexity, Scales, Randomness"), while warmly inviting the broader international community to contribute, exchange ideas, and discuss future trajectories in the numerical analysis and simulation of hyperbolic systems.

SPEAKERS

1. Amelie Porfetye (Heinrich Heine Universität Düsseldorf): Evolution operators in Active Flux methods for the Euler equations.
2. Zhuyan Tang (Johannes Guttenberg Universität Mainz): Active Flux methods for hyperbolic problems: Numerical schemes and convergence analysis.
3. Mingye Na (Johannes Guttenberg Universität Mainz): Structure-preserving numerical methods for the Baer–Nunziato model of compressible multifluid flows.
4. Robert Sauerborn (TU Clausthal): High-Order methods for Euler–Korteweg-type systems.
5. Michele Benedetti (Università di Verona): On novel high-order DG methods with sub-cell FV limiter based on genuinely multidimensional Riemann solvers.
6. Michel Tirapelle (University of Stuttgart): A dissipative generalized Riemann problem for high-order DG methods.
7. Louis Petri (Johannes Guttenberg Universität Mainz): An entropy-stable cut-cell discontinuous Galerkin method with summation-by-parts properties.
8. Gunnar Birke (Universität Münster): An entropy-preserving Domain of Dependence cut-cell stabilization method for hyperbolic PDEs.
9. Hennes Hajduk (TU Dortmund): High-order physics-aware discretizations for convection-dominated problems.
10. Jens Keim (University of Stuttgart): An Entropy-stable DG scheme on hybrid curvilinear meshes.