

ROBUST AND EFFICIENT HIGH-ORDER METHODS FOR PRACTICAL PDE SIMULATIONS

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ABSTRACT

High-order methods can provide high accuracy per degree of freedom and high arithmetic intensity that is well suited for modern computing architectures. Their adoption in industrial and large-scale simulations of partial differential equations (PDEs), however, remains limited by robustness issues for nonlinear, under-resolved, or shock-dominated problems and also by complexity of implementation. Recent developments in methods with provable properties, such as nonlinear stability, conservation, positivity preservation, and well-balancedness, provide a route to reliability. However, these properties often come at the expense of significant increase in computational cost. For these methods to become practical, such properties must be obtained without losing the efficiency that makes high-order methods attractive.

The objective of this minisymposium is to bring together researchers addressing these challenges from complementary directions. Topics include entropy- and energy-stable schemes, positivity-preserving discretizations, limiting, shock capturing, adaptation, and performance-oriented implementations on modern computing platforms. We also seek contributions on high-order operator construction aimed at increasing accuracy per degree of freedom. These include construction of summation-by-parts (SBP) operators, e.g., Padé-type, general-function space, and upwind SBP operators. Constructions that leverage structures such as collocation, sparsity, and tensor-product are also of interest. The overarching goal of the minisymposium is to clarify the trade-offs between accuracy, robustness, operator complexity, discretization cost, and hardware efficiency, and to identify practical directions for deploying robust and efficient high-order methods in industrial and large-scale PDE simulations.

SPEAKERS

1. Jan Nordström (Linköping University and University of Johannesburg, jan.nordstrom@liu.se): Linear and nonlinear energy stability: What is the difference? What do we know? What remains?
2. Jan Glaubitz (Linköping University, jan.glaubitz@liu.se): FSBP Operators for General Function Spaces: Past, Present, and Future.
3. Philipp Rudolf Öffner (Clausthal University of Technology, philipp.oeffner@tu-clausthal.de): Recent advances on FSBP operators and applications to hyperbolic problems
4. Hendrik Ranocha (Johannes Gutenberg University Mainz, hendrik.ranocha@uni-mainz.de): Efficient structure-preserving high-order methods for compressible flows
5. Gregor Gassner (University of Cologne, ggassner@uni-koeln.de): Subcell based shock capturing and AMR
6. Andrew Winters (Linköping University, andrew.winters@liu.se): Nonreflective properties of linearly and nonlinearly stable boundary conditions
7. Ken Mattsson (Uppsala University, ken.mattsson@it.uu.se): TBD
8. David Niemela, supervised by Ken Mattsson (Uppsala University, ken.mattsson@it.uu.se): Accuracy and Robustness with Upwind SBP Operators and Residual-Viscosity Stabilization
9. David Zingg (University of Toronto, david.zingg@utoronto.ca): TBD (first talk)
10. David Zingg (University of Toronto, david.zingg@utoronto.ca): TBD (second talk)
11. Martin Almquist (Uppsala University, martin.almquist@it.uu.se): Compatible sets of boundary-optimized SBP operators
12. Anna Schwarz (University of Stuttgart, andrea.beck@iag.uni-stuttgart.de): Shock capturing for high order DGSEM on curvilinear hybrid meshes
13. Jesse Chan (University of Texas Austin, jesse.chan@oden.utexas.edu): Efficient positivity-preserving techniques for adaptive entropy stable DG methods

14. Spencer Sherwin (Imperial College London, s.sherwin@imperial.ac.uk): Development and optimisation of a device aware Spectral/hp element solver in Nektar++
15. Matt Zahr (Notre Dame University, mzahr@nd.edu): Recent advances in non-linear approximation methods for high-speed flow simulations
16. Gustaaf Jacobs (San Diego State University, gjacobs@sdsu.edu): TBD
17. James Coder (Pennsylvania State University, jcoder@psu.edu): Critical evaluation of high-order and entropy-stable methods for scale-resolving simulation of external turbulent flows
18. Alexander Cicchino (Stanford University, cicchino@stanford.edu): TBD
19. David Kopriva (Florida State University, kopriva@math.fsu.edu): Your mesh affects the reliability and efficiency of your computations, too
20. Magnus Svard (University of Bergen, Magnus.Svard@uib.no): Nonlinearly stable boundary conditions for flow equations.
21. Tristan Montoya (University of Saskatchewan, tristan.montoya@usask.ca): Structure-preserving adaptive high-order methods for land models
22. Nek Sharan (Auburn University, nzs0089@auburn.edu): Energy Stable High-Order Embedded Boundary Method For Practical Turbulent Flows
23. Matteo Parsani (KAUST, matteo.parsani@kaust.edu.sa): TBD
24. Dongze Li, supervised by David Del Rey Fernandez (University of Waterloo, d336li@uwaterloo.ca): Entropy stable shock tracking for the compressible Navier–Stokes equations
25. Devin Blankespoor, supervised by David Del Rey Fernandez (University of Waterloo, devin.blankespoor@uwaterloo.ca): Energy stable SBP discretizations of the skew-symmetric formulation of the compressible Navier–Stokes equations
26. Gaia Noseworthy, supervised by David Del Rey Fernandez (University of Waterloo, gaia.noseworthy@uwaterloo.ca): Energy stable SBP discretizations of the skew-symmetric formulation of the incompressible Navier–Stokes equations
27. Kenny Wiratama, supervised by Kenneth Duru (University of Texas at El Paso, kduru@utep.edu): Stable and Adjoint Consistent High Order Perfectly Matched Layer Discretization for Waves

28. Rongping Tang, supervised by Kenneth Duru (University of Texas at El Paso, kduru@utep.edu): A stable DG-based optimisation framework for computing MRxMHD equilibrium