CFC 2023 minisymposium proposal

Property-preserving finite element methods for computational fluid dynamics

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ABSTRACT

Recent years have seen significant interest of the finite element community in high-order methods that preserve certain properties of exact solutions and/or differential operators. The design criteria for the development of such methods may include, e.g., local discrete maximum principles for scalar quantities of interest, global positivity preservation, kinetic energy preservation, and/or entropy conditions. In the presence of source terms, it may be essential to ensure well balancing, i.e., preservation of important steady-state equilibria (such as "lake at rest" in shallow water models). Additionally, the impact of unstructured grids, non-conforming approximations, super-parametric elements, boundary conditions, numerical quadrature rules and time discretization procedures needs to be taken into account.

Algorithmic tools for enforcing the desired properties include artificial diffusion operators, flux/slope limiters, convex blending, and the summation-by-parts formalism. As a rule, only nonlinear numerical approximations can meet the conflicting demands for high accuracy and validity of all relevant constraints. The need to deal with challenging nonlinear problems requires new approaches to the analysis and design of property-preserving finite element methods. Exploration of such approaches is currently under way, and the state of the art is rapidly evolving. This minisymposium will bring together numerical analysts and computational mathematicians who have made important contributions to the field. Other prospective participants will be invited to present their work on nonlinear stabilization or limiting techniques for finite elements. The minisymposium will enable developers of continuous and discontinuous Galerkin methods to synchronize their efforts and further advance both approaches. The applications to be discussed range from scalar conservation laws to the equations of compressible gas dynamics, magnetohydrodynamics, and geophysical fluid dynamics.

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