

HIGH-ORDER STRUCTURE PRESERVING METHODS

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ABSTRACT

The computational modeling of complex physical systems in sustainable design, healthcare, and engineering requires accurate, efficient, and problem-specific predictive methods. Standard numerical discretizations often struggle to preserve key physical invariants and mathematical structures, leading to unphysical approximations that compromise reliability. This minisymposium aims to bring together experts in advanced numerical strategies that overcome these issues through structure-preserving and physically consistent methods.

The session spans three main methodological frameworks. First, we explore high-order structure-preserving discretizations – such as polytopal discontinuous Galerkin, virtual element, and Trefftz methods – tailored for complex dynamics, including incompressible and magnetohydrodynamic flows, fractured media, and wave propagation. Second, we discuss structure-preserving model order reduction for parametrized PDEs, including hyper-reduction, neural network-based nonlinear approximations, and closure models designed for transport-dominated or shock-driven phenomena. Third, we aim at combining these methods with data integration and data assimilation to preserve physical consistency in the context of noisy and sparse data.

SPEAKERS

1. Clarissa Astuto (Università di Catania): “An Asymptotic Preserving and Accurate Scheme for Multiscale Poisson-Nernst-Planck (MPNP) system.”
2. Massimo Frittelli (Università del Salento): “Numerical preservation of invariant regions for reaction-diffusion systems”.
3. Stefano Pagani (Politecnico di Milano): “Learning Structure-Preserving Surrogate Models for Dynamical Systems”.
4. Ralf Hiptmair (ETH Zürich): “FEEC for the Trace De Rham Complex”.
5. Giovanni Russo (Università di Catania): “Adaptive Fourier-Spectral methods for the Vlasov-Poisson system”.
6. Stefano Scialò (Politecnico di Torino): “Efficient numerical treatment of large scale mixed-dimensional problems”.
7. Francesca Rapetti (Université Cote d’Azur): “A dimensionally reduced model for strongly anisotropic heat diffusion”.