UNIVERSITY of HOUSTON

Department of Mathematics

Scientific Computing Seminar

Thursday, September 18, 2025
1 PM- 2 PM
Room 646 PGH

(I) **Speaker**: Mark Simmons, Department of Mathematics, University of Houston

Title: A novel time discretization scheme for the incompressible three-phase flow problem in porous media

Abstract: The sequential approach to solving the incompressible three-phase flow problem in porous media has become popular due to its ability to handle large-scale computations. However, a key drawback of this method is the need to recompute the stiffness matrices at each time step after discretization. In this presentation, we introduce a novel time discretization scheme that, under certain conditions, produces time-independent stiffness matrices for two of the three primary unknowns. We then perform a time-error analysis for one of these unknowns and validate its convergence properties. The resulting method is first-order accurate in time and demonstrates stability when applied to large-scale numerical simulations in highly heterogeneous domains.

(II) **Speaker**: Md Amran Hossan Mojamder, Department of Mathematics, University of Houston

Title: Parametrization of sub-grid scales in long-term simulations of the shallow-water equations using machine learning and convex limiting.

Abstract: We present a method that combines machine learning with flux limiting for sub-grid scale modeling in flux-limited finite volume schemes for the one-dimensional shallow-water equations. In our approach, the numerical fluxes of a target conservative scheme are learned by fitting coarse-mesh averages to the results of a monotone fine-grid discretization, with a neural network representing the sub-grid-scale contributions. To guarantee positivity and compliance with local maximum principles, we apply a flux limiter that restricts the intermediate states in the fluctuation form to remain within a convex admissible set. Numerical experiments show that this hybrid method—machine learning combined with monolithic convex limiting—provides reliable closures, even in cases not included in the network's training data.

(III) **Speaker**: Md Rezwan Bin Mizan, Department of Mathematics, University of Houston

Title: Tensorial Reduced Order Modeling for Parametric Viscoplastic Fluid Dynamics

Abstract: Parametric studies of complex fluid flows require extensive computational resources when exploring high-dimensional parameter spaces using full-order models. This talk presents a tensorial reduced order modeling (TROM) framework that addresses this challenge for shallow water equations governing the Herschel-Bulkley viscoplastic dam-break flows.

We construct six-dimensional snapshot tensors encompassing spatial coordinates, four physical parameters (yield stress, upstream/downstream depths, and bed slope), and temporal evolution. The approach utilizes Tucker decomposition to exploit low-rank structure in the solution manifold. The framework operates in two phases: an offline phase generating solution snapshots across the parameter space and computing their Tucker decomposition, and an online phase providing rapid evaluation for new parameter combinations.

Two reconstruction strategies are implemented: an intrusive approach performing time integration in reduced coordinate space via Galerkin projection, and a non-intrusive method directly reconstructing complete solution trajectories without temporal integration.

Numerical results demonstrate that this framework offers substantial computational savings while retaining predictive accuracy, making it an efficient reduced order modeling tool for geophysical and environmental flows.

(IV) **Speaker**: Anton Myshak, Department of Mathematics, University of Houston

Title: Application of PINNs for the Shallow Water Dam Break Problem

Abstract: We present a PINN framework tailored to one-dimensional shallow water flows under both dry-bed (zero downstream depth) and wet-bed regimes. By formulating data-fitting and PDE residual losses as mean absolute error (MAE) and enforcing boundary conditions via mean squared error (MSE), our PINN effectively balances fitting the observed data with respecting the underlying physics. We also compute the PDE residual on both collocation points and data points, which helps calibrate training and the physics constraint weight. Our model yields uniformly smooth predictions of depth h and velocity u both within the training range (interpolation) and beyond it (extrapolation), while purely data-driven networks often exhibit nonphysical oscillations, especially near shock fronts. The PINN accurately captures shock dynamics, offering a robust, mesh-free alternative for rapid, accurate shallow water simulations.

This seminar is easily accessible to persons with disabilities. For more information or for assistance, please contact the Mathematics Department at 743-3500.