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PETIGA: HIGH-PERFORMANCE ISOGEOMETRIC ANALYSIS OF PHASE-FIELD MODELS

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We have developed fast implementations of B-spline/NURBS based finite element solvers, written using PETSc. PETSc is frequently used in software packages to leverage its optimized and parallel implementation of solvers, however we also are using PETSc data structures to assemble the linear systems. These structures in PETSC (called DAs) were originally intended for the parallel assembly of linear systems resulting from finite differences. We have reworked this structure for linear systems resulting from isogeometric analysis based on tensor product spline spaces. The result of which is the PetIGA framework for solving problems using isogeometric analysis which is scalable and greatly simplified over previous solvers.

Our infrastructure has also allowed us to develop scalable solvers for a variety of problems. We have chosen to pursue nonlinear time dependent problems [1, 2], such as:

- Cahn-Hilliard
- Navier-Stokes-Korteweg
- Variational Multiscale for Navier-Stokes
- Diffusive Wave Approximation to Shallow Water Equations
- Phase-Field Crystal (PFC) equation and its time integration
- Divergence-conforming B-spline modeling of nanoparticle suspensions

We also have solvers for an assortment of linear problems: Poisson, elasticity, Helmholtz, thin shells, advection-diffusion, and diffusion-reaction. All solvers are written to be inherently parallel and run on anything from a laptop to a supercomputer such as Shaheen, KAUSTs IBM-BlueGeneP supercomputer. In this presentation we will focus on new time integration techniques for phase-field modeling which are energy stable and allow for stable linearizations of the underlying non-linear model [3].

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