# Enabling Scalable Multiphysics Simulations through Block Preconditioning

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**ABSTRACT**

Recent work has demonstrated that block preconditioning can scalably accelerate the performance of iterative solvers applied to linear systems arising in implicit multiphysics PDE simulations. The idea of block preconditioning is to decompose the system matrix into physical sub-blocks and apply individual solvers to each sub-block. It can be advantageous to block into simpler segregated physics systems or to block by discretization type. This strategy is particularly amenable to multiphysics systems in which existing solvers, such as multilevel methods, can be leveraged for component physics and to problems with disparate discretizations in which scalable monolithic solvers are rare. General block preconditioning techniques include block Jacobi and block Gauss-Seidel methods as well as more sophisticated strategies based on approximate block factorizations that attempt to capture off-diagonal couplings in block diagonal Schur complement approximations.

This talk discusses the mathematical motivation of block preconditioning in the context of a continuum plasma model that employs a compatible discretization of the Maxwell equations. This model results in particularly complex linear systems as it features both disparate discretizations and stiff time-scales resulting from off-diagonal coupling. We motivate block preconditioners for these systems that allow reuse of existing multigrid solvers for different degrees of freedom while capturing important couplings. We will present results that demonstrate the algorithmic scalability of block preconditioning techniques for complex multiphysics systems integrated at time-scales of interest.