Thiele, Christopher; Riviere, Beatrice

*p*-multigrid with partial smoothing: an efficient preconditioner for discontinuous Galerkin discretizations with modal bases. (English) Zbl 07415983


Summary: Multigrid methods are efficient tools for the solution of linear systems arising in the discretization of partial differential equations and in other applications. While traditional multigrid methods often exhibit optimal or near-optimal computational cost, their application to advanced discretizations and complex geometries is challenging. In this work, we combine *p*-multigrid methods with algebraic multigrid (AMG) techniques to obtain scalable preconditioners for modal discontinuous Galerkin discretizations on complex, three-dimensional domains. We introduce the notion of partial smoothers, which update only a subset of the unknowns at each level of the multigrid hierarchy. Using partial smoothing, we incorporate hierarchical scale separation (HSS), a two-level *p*-multigrid-like technique with a more complete separation of high-order and low-order unknowns, into the existing *p*-multigrid framework. The resulting *p*-multigrid methods with partial smoothing are a generalization of existing HSS methods, offering tradeoffs between *p*-multigrid convergence and computational performance. In numerical experiments, we show that combined *p*-multigrid-AMG preconditioners can significantly accelerate large-scale simulations of pore scale flow, and we demonstrate that partial smoothing can further reduce computational cost by as much as 23%.

MSC:

65Nxx Numerical methods for partial differential equations, boundary value problems
65Fxx Numerical linear algebra
35Jxx Elliptic equations and elliptic systems

Keywords:

*p*-multigrid; hybrid parallelism; discontinuous Galerkin methods; pore scale flow

References:

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