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Coarse Grid Representations of the Near Nullspace in an Energy Minimizing Multigrid

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Solving linear systems arising from multi-physics simulations is challenging, especially when the underlying model has boundary layers, stretching, or discontinuities. We have developed an algebraic multigrid method to address such issues. This method can be viewed as solving a constrained optimization problem. *A priori* sparsity patterns and interpolation of low-energy error modes are constraints in an energy minimization process that can yield an AMG preconditioner with low operator complexity and good convergence properties. This method allows for considerable freedom in choosing the number of coarse degrees of freedom per node as well as the coarse representation of the low-energy modes. This gives rise to certain questions, such as how to compress near-nullspace information and how to enforce coarse near-nullspace orthogonality in order to have an amenable minimization problem. We discuss various answers to these questions and their implications for the solver, and illustrate with numerical experiments that the resulting multigrid methods can be effective, especially for linear equations arising from systems of PDEs.