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On the Reuse of Multiscale Basis Functions for the Approximation of Time-dependent Problems

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In the formulation of multiscale methods for second order elliptic equations that are based on domain decomposition procedures, (see e.g. the Multiscale Mortar Mixed Finite Element Method (MMMFEM) [1], the Multiscale Mixed Method (MuMM) [2], Multiscale Robin Coupled (MRC) [3], the Multiscale Hybrid - Mixed Finite Element Method (MHM) [4]) typically the computational domain is decomposed into subdomains, and for each subdomain a set of multiscale basis functions is numerically constructed. Consider the application of such a method to solve a multiphase flow problem [5] or in a Markov chain Monte Carlo (McMC) uncertainty quantification study with a random walk sampler [6]. In these problems (from a time step to the next, for the flow problem and from one sample to the next, for the McMC study) in principle, the multiscale basis functions should be recomputed because the coefficients of the underlying PDE will change. However, these changes are typically small. Thus, instead of calculating again all the multiscale basis function, we investigate the possibility of finding an approximate solution for the equation with modified coefficients using simple perturbation theory, followed by a downscaling step (needed to recover fine grid velocity fields for transport calculations). In this presentation, we focus on the MuMM [2], and we show that, in fact, the perturbation theory may produce accurate solutions, while taking advantage of multiscale basis function associated with the elliptic equation with distinct coefficients.

An efficient parallel algorithm is implemented in multi-core machines. Numerical experiments, where the perturbation theory results are compared with direct fine grid solutions, are presented and discussed.

References

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