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Preconditioned iterative solvers for the multi-level *hp*-adaptive finite cell method

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The finite cell method [1] is a fictitious domain method in which a complex geometry—on which a problem is posed—is immersed in a geometrically simple, high order, embedding mesh. This mitigates the computationally expensive burden of generating boundary conforming discretizations, and enables a cheap and efficient implementation of multi-level *hp*-finite element discretizations [2, 3].

It is well known that the finite cell method is prone to conditioning problems, when the background mesh contains cut elements that only marginally intersect the problem domain [4]. This impedes the convergence of iterative solvers, and often compels researchers to resort to direct solvers [5]. In [6], it is suggested to precondition the finite cell method by an Additive Schwarz preconditioner. It is demonstrated that the conditioning problems are resolved when *each* cut element contributes the set of *all* its supported basis functions to the matrix partitioning. This is an efficient solution for the tensor product bases employed in [6], since the number of basis functions supported on one element is constant and bounded for such discretizations. In the multi-level *hp*-adaptive finite cell method, the number of basis functions supported on an element is not constant however, and can be much larger when multiple levels of refinements are employed. Consequently, the proposed preconditioning technique is computationally expensive and potentially sub-optimal for the multi-level *hp*-adaptive finite cell method.

In this pair presentation we demonstrate that it is not required to utilize a set with *all* basis functions supported on a cut element, and develop a preconditioner based on a *restricted* set of basis functions. This results in an effective preconditioning technique for the multi-level *hp*-adaptive finite cell method. We show that this preconditioner enables the application of iterative solvers for finite cell systems of a size that is prohibitive for the application of a direct solver.

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