Two-Level Methods for the Simulation of Additive and Nonhomogenous Material Problems

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ABSTRACT

Problems with nonhomogenous material properties arise frequently in many applications and are a well-known source of difficulty in numerical simulations. This problem arises often in numerical simulations of additive manufacturing, as physics of the problem are significantly more complex near the heat source, a small portion of the computational domain overall, requiring one to use a significantly finer mesh in this region compared to elsewhere in the domain. This can make the use of a uniform mesh numerically unfeasible and, while nonuniform meshes can be employed, these may be challenging to generate and make preconditioning more difficult. While other approaches, such as adaptive refinement and derefinement techniques, address this problem effectively, they are often computationally expensive and difficult to implement. We propose an alternative approach, a two-level technique related to the Fat boundary method [1], in which we use a split-problem formulation. We may then solve the coupled subproblems on two separate meshes: a coarser *global* mesh over the whole domain and a fine *local* mesh defined only in the heating region. We present the proposed method, discuss several important mathematical results, and demonstrate its applicability on a series of idealized two-dimensional test cases.

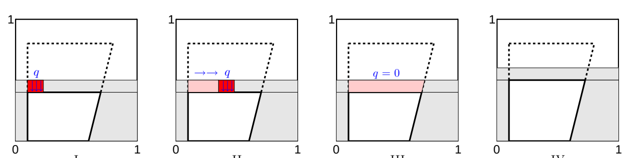

Figure 1: Ex. of additive problem: majority of the difficulty within top layer, motivating a two-level approach.

REFERENCES

[1] S. Bertoluzza, M. Ismail, and B. Maury. Analysis of the fully discrete fat boundary method, *Numerische Mathematik*, 118: 49–77, 2011.

[2] A. Viguerie, S. Bertoluzza, and F. Auricchio. A Fat Boundary-type Method for Localized Nonhomogeneous Material Problems.