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A posteriori error estimation and adaptive strategy for the control of MsFEM computations

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Abstract

We introduce quantitative and robust tools to control the numerical accuracy in simulations performed using the Multiscale Finite Element Method (MsFEM). First, we propose a guaranteed and fully computable *a posteriori* error estimate for the global error measured in the energy norm. It is based on dual analysis and the Constitutive Relation Error (CRE) concept, with recovery of equilibrated fluxes from the approximate MsFEM solution. Second, the estimate is split into several indicators, associated to the various MsFEM error sources, in order to drive an adaptive procedure. The overall strategy thus enables to automatically identify an appropriate trade-off between accuracy and computational cost in the MsFEM numerical simulations. Furthermore, the strategy is compatible with the offline/online paradigm of MsFEM. The performances of our approach are demonstrated on several numerical experiments.

Key words: Multiscale problems; MsFEM approach; A posteriori error estimation; Adaptivity

1. Introduction and objectives

Developing multiscale numerical methods for mechanical problems with highly heterogeneous material structure is an increasingly active research field. Such methods are becoming a standard approach in Material Sciences and Computational Mechanics. As an alternative to solving a full fine-scale problem, with a usually prohibitive computational cost, multiscale modeling aims at linking the different scales for the accurate description of physical phenomena and/or the prediction of macroscopic properties (effective conductivity, elastic moduli, ...). One of the goals is to capture the impact of the smaller scales on the larger scales, in order to observe the influence of the microscopic structure on the macroscopic behavior.

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