Multiscale hybrid methods for time-domain electromagnetics

S. Lanteri*, R. Léger*, D. Paredes$, C. Scheid*#, F. Valentin♣

* Inria Sophia Antipolis – Méditerranée
2004 route des Lucioles - BP 93
06902 Sophia Antipolis Cedex, France
Stephane.Lanteri@inria.fr/Raphael.Leger@inria.fr

$ Pontificia Universidad Catòlica de Valparaìso, Instituto de Matemáticas
IMA/PUCV, Blanco Viel 596, Cerro Barón, Valparaíso, Chile
Diego.Paredes@ucv.cl

University of Nice Sophia Antipolis, J. A. Dieudonné Laboratory
Parc Valrose, 06108 Nice, Cedex 02, France
Claire.Scheid@unice.fr

♣ Applied Mathematics Department
National Laboratory for Scientific Computing – LNCC
Av. Getulio Vargas, 333, 25651-070 Petropolis - RJ, Brazil
valentin@lncc.br

ABSTRACT

In this work, we are interested in the propagation of electromagnetic waves in complex media. More precisely, we would like to study time dependent wave propagation problems with strong multiscale features (possibly in space and time). In this context we would like to contribute in the design of innovative numerical methods particularly well suited to the simulation of such problems. Indeed when a PDE model is approximated via classical finite element type method, it may suffer from a loss of accuracy when the solution presents multiscale features on coarse meshes. To address this issue, we rely on the concept of multiscale basis functions that is one solution to allow for accuracy even on coarse meshes. These basis functions are defined via algebraic relations. Contrary to classical polynomial approximation, they render by themselves a part of the high-contrast features of the problem at hand. Recently, a new family of finite element methods has been introduced in [1]-[2], referred as "Multiscale Hybrid-Mixed methods" (MHM), which is well adapted to the simulation of high-contrast or heterogeneous problems. The underlying approach relies on a two level discretization. Shortly, basis functions computed on a fine (second level) mesh allow for the reconstruction of the solution on a coarse (first level) mesh. Such MHM have been initially designed in the context of stationary problems, such as Darcy flows. In this work, we propose to extend the concept of MHM to time dependent electromagnetic wave propagation problems. The model problem relies on the time dependent Maxwell's equations. The continuity of the electric field is relaxed via the introduction of a Lagrange multiplier. The solutions are expressed on a basis computed at the second level that incorporates the heterogeneity of the problem via the resolution of a PDE. Several schemes are proposed from implicit to explicit time schemes and continuous finite elements to discontinuous ones for the spatial discretization of the local problems at the second level.

REFERENCES

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