# Multiscale Hybrid-Mixed Method for the Simulation of Nanoscale Light-Matter Interactions

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## Abstract

In this work, we address time dependent electromagnetic wave propagation problems with strong multiscale features with application to nanophotonics, where problems usually involve complex multiscale geometries, heterogeneous materials, and intense, localized electromagnetic fields. Nanophotonics simulations require very fine meshes to incorporate the influence of geometries as well as high order polynomial interpolations to minimize dispersion. Our goal is to design a family of innovative high performance numerical methods perfectly adapted for the simulation of such multiscale problems. For that purpose we extend the Multiscale Hybrid-Mixed (MHM) finite element method, originally proposed for the Laplace problem in [2], to the solution of 2d and 3d transient Maxwell equations with heterogeneous media. The MHM method arises from the decomposition of the exact electromagnetic fields in terms of the solutions of locally independent Maxwell problems. Those problems are tied together with an one field formulation on top of a coarse mesh skeleton. The multiscale basis functions, which are responsible for upscaling, are also driven by local Maxwell problems. A high order Discontinuous Galerkin method (see [1]) in space combined with a second-order explicit leap-frog scheme in time discretizes the local problems. This makes the MHM method effective and parallelizable, and yields a staggered algorithm within a "divide-and-conquer" framework. In this study this MHM-DGTD method has been implemented in 2d. Several numerical tests assess the optimal convergence of the MHM method, as well as its accuracy to simulate nanophotonic device on coarse meshes.

## References

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