SPECTRAL AND HIGH ORDER DGFEM FOR TIME-DOMAIN ELECTRODYNAMICS IN INHOMOGENEOUS MATERIAL

Jens Zudrop\(^1\), Harald Klimach\(^2\)

\(^1\) German Research School for Simulation Sciences, RWTH Aachen, Schinkelstr. 2a, 52062 Aachen, \{j.zudrop\}@grs-sim.de
\(^2\) Simulation Techniques & Scientific Computing, Hölderlinstr. 3, 57076 Siegen, \{jens.zudrop, harald.klimach\}@uni-siegen.de

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This contribution is concerned with the efficient and scalable numerical solution of time-domain electrodynamics. We consider the medium to high frequency range, which is dominated by wave phenomena, in inhomogeneous optical material. This requires numerical methods with high accuracy, i.e. low numerical dissipation and small dispersion errors, capable of dealing with varying material parameters. Recently, high order (in space) - explicit (in time) Discontinuous Galerkin Finite Element Methods (DGFEM) have become a promising candidate for wave-dominated problems [1] and are widely deployed in a variety of implementations.

In this talk we present further algorithmic improvements to the DGFEM to extend it into the spectral regime (order > 100) and emphasize the possibility to embed complex geometries. These improvements rely on properly defined fast algorithms for spectral DGFEM on octrees, turning them into efficient alternatives. We embed inhomogeneous material parameters in our model formulation, which allows us to handle complex geometrical obstacles with high order accuracy [5]. Even in the case of discontinuous material parameters, a properly defined post-processing technique (e.g. spectral mollifier) enables us to recover spectral pointwise error convergence [2], [4]. Numerical experiments prove the accuracy and efficiency of the proposed method for the presented application domain.

In addition, the algorithmic concept is robust and intrinsically scalable. We present a fully parallel implementation (from pre-processing over the solver to post-processing), which exploits the computing power of modern, massively parallel computing systems [3]. The software framework scales to more than 100k processes and enables us to scale down to one element per compute node by a hybrid parallelization in distributed and shared memory (MPI + OpenMP). This strategy allows us to fine tune the numerical method to
the available compute resources by choosing the element sizes accordingly. We therefore are able to apply the method to realistic, large scale engineering applications.

REFERENCES


