Discontinuous Galerkin Finite Element Time Domain Method for Solving Maxwell equations

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Although the Finite Difference Time Domain (FDTD) is dominating the modeling of electromagnetic systems involving heterogeneous media, other approaches are investigated to achieve better accuracy and efficiency for solving ever increasing complex electromagnetic problems. The underlying regular orthogonal grid of the FDTD; which explains its simplicity and performance, limits its ability to tackle efficiently arbitrarily geometries and fine details. Amongst possible approaches are locally modified FDTD, sub-gridding techniques. Finite Element Time Domain methods are naturally able to conform its mesh to the geometry but the algorithms are generally implicit requiring a matrix solving at each time step. Mass-lumping technique is not straightforward for general meshes like tetrahedral ones. Recently, discontinuous Galerkin methods have been proposed in solving Maxwell equations in time domain. It uses local basis functions which can be high order ones within each element to decompose the electromagnetic fields. The fields within elements are connected through the centered mean approximation of the surface integrals of the finite element formulation. In finite element framework, this is quite unusual as generally the continuity through elements are features of the basis functions. The time step algorithm uses the classical leap-frog scheme. This technique presents many interesting features. The formulation applies to orthogonal hexahedral meshes and to tetrahedral meshes as well. For the first kind of meshes, similarities with the Transmission Line Matrix (TLM) using symmetrical condensed node can be found. For tetrahedral meshes, it can be seen as a way to make the algorithm explicit as only small size matrices need to be solved. The algorithm verifies the conservation of a discrete energy for different order of the basis functions whose property can be verified also when using non-conforming meshes. Despite a higher number of degrees of freedom, this technique is promising as a flexible way to tackle explicit and stable schemes and further enabling combinations of non-conforming meshes and different order basis functions.