Locally implicit and implicit discontinuous Galerkin time domain method for electromagnetic wave propagation in dispersive media

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We are concerned with the numerical simulation of electromagnetic wave propagation in dispersive media i.e. when the electromagnetic material characteristics depend of the frequency. In the time-domain, this translates in a time dependency of these parameters that can be taken into account through an additional differential equation for, e.g, the electric polarization, which is coupled to the Maxwell's equations which is a PDE system. We propose and analyze two efficient time integration methods for dealing with grid induced stiffness when using non-uniform (locally refined) meshes and use these methods to study the interaction of electromagnetic waves with biological tissues.
On the one hand the first method is a fully implicit method in time with a hybridizable discontinuous Galerkin method to decrease the number of degrees of freedom and on the other hand the second method is a locally implicit method blending the second order leap-frog scheme and the second order Crank-Nicolson scheme. A particular attention is payed to show that this method retains its second-order ODE convergence under stable simultaneous space-time grid refinement $\Delta t \backsim h$, $h \to 0$ towards the exact PDE solution.
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