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UC|UP MATH PhD Program

Research Seminar Program

UC|UP Joint PhD Program in Mathematics

Date and Time. September 24, 2015 - 14h00

Place. Room M031, Department of Mathematics, University of Porto

Speaker. Maryam Khaksar Ghalati [1]

Title. Numerical Solution of Time-Dependent Maxwells equations in Anisotropic Materials for Modelling Light Scattering in Human Eyes Structure

Abstract. Modelling light propagation in biological tissue has become an important research topic in biomedical optics with application in diverse fields as for example in ophthalmology. Waveguides with induced anisotropy may worth to be modeled as they could play a role in biological waveguides. For instance, there is a strong correlation between retinal nerve fiber layer thinning and reduction in tissue birefringence. Simulating the full complexity of the retina, in particular the variation of size and shape of each structure, distance between them and refractive indexes, re- quires a rigorous approach that can be achieved by solving Maxwells equations. The finite difference time domain method (FDTD) was the first commonly used technique to find a time-domain solution of Maxwells curl equations on spatial grids. In the last decades, many papers in electromagnetic simula- tions have shown interest in discontinuous Galerkin time domain methods (DGTD) to solve Maxwells equations. The DGTD methods presents some well-known major advantages compared with more classical FDTD and finite element time domain methods. In opposition to the traditional FDTD methods, the DGTD method is a high-order accurate method that can easily handle complex geometries. Moreover, the method is suitable for parallel imple- mentation on modern multi-graphics processing units and local refinement strategies can be incorporated due to the ability of the method to deal with irregular meshes with hanging nodes and local spaces of different orders. This also represents an advantage when compared also to finite element methods. Despite the relevance of the anisotropic case, most of the formulation of the DGTD methods have been restricted to isotropic and dispersive materials. In this work we consider models with anisotropic permittivity tensors which arise naturally in our application of interest. Here we combine the DGTD method (considering central and upwind fluxes) with a leap-frog type time integration, arriving at a fully-discrete explicit leap-frog DG scheme. We give a rigorous proof of the stability and the high-order convergency of the scheme. We provide some numerical tests which illustrate the theoretical results.

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