High order curvilinear DGTD methods for local and nonlocal plasmonics

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The DGTD (Discontinuous Galerkin Time-Domain) method has emerged in nanophotonics in the recent years [1] as a complementary or alternative modeling approach for time-domain nanoscale light-matter interactions beside the widely used FDTD (Finite Difference Time-Domain) method. A DG method [2] can be seen as a classical Finite Element (FE) method for which the global continuity of the approximation is lifted. Similarly to a FE method, the physical unknowns are approximated on a finite set of basis functions. However, for DG, the support of basis functions are restrained to a single discretization cell. Hence, the solution produced by a DG method is discontinuous (similarly to finite volumes), and different field values are stored for each element interface degree of freedom. The three main consequences are that (i) a DG method naturally handles material and field discontinuities, (ii) the weak formulation is local to an element, implying no large mass matrix inversion in the solving process if an explicit time scheme is used, and (iii) the order of the polynomial approximation in space can be made arbitrarily high by adding more degrees of freedom inside the elements. The connection between cells is restored by the use of a numerical flux. The discontinuity of the approximation makes room for numerous methodological improvements, such as efficient parallelization or the use of non-conforming and hybrid meshes A DG method os also very flexible with regards to time integration, motivating the design of local time stepping as well as locally implicit strategies. In the quest of higher accuracy and lower time to solution, a tailored treatment of the approximation of curvilinear geometrical features [3] is worth considering, especially in the presence of nanogaps or when assessing imperfect design of nanostructures. The use of very coarse discretization meshes leveraging tetrahedral curvilinear elements for the simulation of three-dimensional nanoscale light-matter interactions is assessed in this study, which is conducted in the framework of high order DGTD methods for solving the system of Maxwell equations coupled to a generalized model of local dispersion effects [3], as well as to a (linearized) hydrodynamic Drude model [4] for dealing with nonlocal dispersion effects [5].

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1. **Title of the paper**
   High order curvilinear DGTD methods for local and nonlocal plasmonics

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   Advanced computational methods for nano-optical applications
   Organized by Prof. Ozgur Ergul (Middle East Technical University) and
   Prof. Shinichiro Ohnuki (Nihon University)