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ABSTRACT BOOKLET

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Finite-difference analysis of high demanding computational problems in optical periodic nonlinear media

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Title: Finite-difference analysis of high demanding computational problems in optical periodic nonlinear media

The application of nonlinear materials in photonic crystals and periodic optical media in general has been extensively investigated in literature but currently numerical simulation, which is necessary in the design of sophisticated photonics devices, is very challenging. The Split-Field Finite-Difference Time-Domain (SF-FDTD) approach is a formulation of FDTD that is specially tailored to efficiently incorporate the periodicity in the algorithm and provides a natural framework for simulating periodic optical media under oblique angle of incidence. Here, this formalism has been adapted for covering second- and third- order nonlinear materials with a tensorial formulation of both nonlinear susceptibilities. Even the method only considers a single period of the structure, the addition of nonlinear materials sets some issues that must be addressed. Firstly, the nonlinear dependence of the electromagnetic field, which is included due to the nonlinear polarization term, must be solved in each time step by means of an additional fixed-point iterative process. Hence, the computational intensity of the method is dramatically affected. Secondly, considering the tensorial behaviour of the second and third-order nonlinear susceptibilities establishes a challenge in terms of computational resources. In order to avoid these drawbacks, High- Performance Computing (HPC) solutions based on GPU and Intel Xeon Phi have been considered. The SF-FDTD method here presented gives the possibility of accurately analyse phenomena such as the second harmonic generation in second-order nonlinear materials, shifting of resonances in resonant gratings due to Kerr effect, bistability effects and all- optical behaviour in two-dimensionally binary gratings with nonlinear material filling the pillars.