Higher-order methods for simulating light propagation and light-matter interaction in nano-photonic systems

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Abstract :

Time-domain simulations play a very prominent role in the investigation and design of micro- and nano-photonic structures. In many cases, these strongly scattering systems need to be modelled on long time-scales with high precision. Such high accuracy, combined with unconditional stability and efficient performance, can be achieved via an operator-exponential method based on Krylov-subspace techniques [1].

This approach is capable of handling optically anisotropic, lossy and dispersive materials as well as CFS-PML boundary conditions. Furthermore, the use of discontinuous Galerkin methods on unstructured grids allows the realization of high-order spatial discretization schemes which ideally complement the time-stepping capabilities of the Krylov-subspace approach. It is straightforward to extend the scheme to handle nonlinear wave propagation and wave mixing phenomena as well as to treat the dynamics of coupled systems.

Thus, this approach is very well suited to study most experimentally relevant photonic nano-structures and we present results of strongly non-Markovian dynamics associated with spontaneous emission in Photonic Crystals [2] as well as cross sections and field enhancements in certain nano-plasmonic systems [3,4].

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