Modelling open nanophotonic structures using the Fourier modal method in infinite domains

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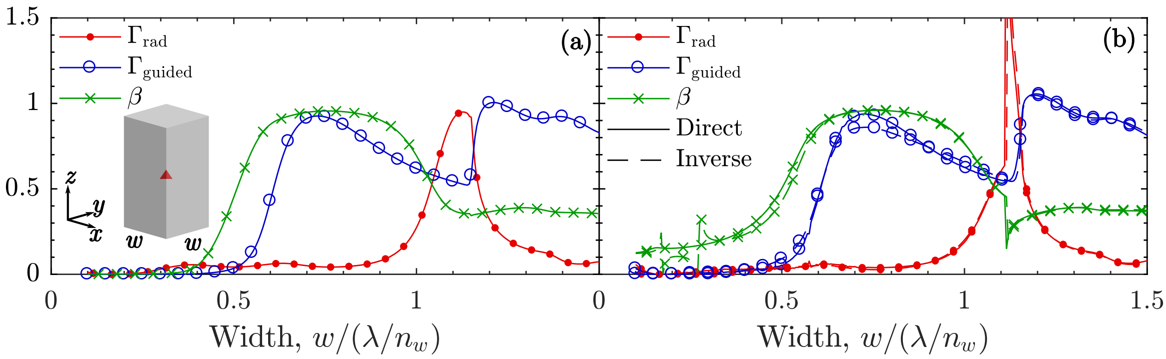
We present an open-geometry Fourier modal method (oFMM) for simulating nanophotonic structures in infinite domains with open boundary conditions. Our results show that a non-uniform sampling of the k-space is essential for convergence.

3D open geometry Fourier modal method

The Fourier modal method (FMM) in Cartesian coordinates uses Fourier series as the expansion basis. This implies periodic boundary conditions (BCs), which is advantageous for periodic structures like photonic crystals, however, the periodic BCs leads to parasitic reflections in open geometries from the leaky modes. This can be overcome by using absorbing boundaries, such as perfectly matched layers (PMLs), but convergence of PMLs towards an open geometry limit is generally not obtained. [1]. Instead of PMLs open boundary conditions can be used and recently this was developed for structures having cylindrical symmetry [2], where a non-uniform sampling of the k-space was shown to outperform the standard equidistant k-space discretization.



Normalised emission rates for an on-axis x-oriented dipole in an infinte square nanowire computed with (a) a non-uniform sampling and (b) using a standard equidistant sampling of the k-space.

In this work we have developed an open-geometry Fourier modal method with open boundary conditions in 3D Cartesian coordinates. Our results show that a non-uniform sampling of the k-space is essential to obtain good convergence especially for the leaky modes. This is seen in the figure, where the emission rate into the guided modes is well described with both discretization schemes, but the radiation modes are poorly described with the equidistant grid (b).

References

[1] J. R. de Lasson, "Modeling and simulations of light emission and propagation in open nanophotonic systems," Ph.D. thesis, Technical University of Denmark (2015).

[2] T. Häyrynen, J. R. de Lasson, and N. Gregersen, "Open-geometry Fourier modal method: modeling nanophotonic structures in infinite domains," J. Opt. Soc. Am. A **33**, 1298–1306 (2016).