Fast wide-angle BPMs using complex Jacobi iteration

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We propose an adaptation to the recently introduced complex Jacobi iteration for the fast solution of wide-angle (WA) beam propagation methods (BPMs). The beam propagation equation is based on two approximant methods including the conventional Hadley(1,1) and the recently proposed KP(1,1) approximant.

Introduction

Efforts to improve the limitations of the paraxial approximation in the beam propagation method have so far made use of wide-angle formulations. Different treatments of WA-BPM based on the slowly varying envelope approximation (SVEA) have been developed. There exist real Padé approximant operators mentioned here as Hadley(m,n) [1] and complex Padé approximant operators [2]. In addition, treatments of WA-BPM without having to make the SVEAs have also been reported, including the series expansion technique of the propagator, the split-step of beam propagation equation and the rational KP(m,n) approximant we recently proposed [3].

For Hadley(1,1) and KP(1,1) approximant-based beam propagation of wave profiles within a 2D cross section, the beam propagation equation can be cast in terms of a Helmholtz equation with source term, but that equation needs to be solved efficiently since numerous propagation steps are routinely required during the course of a problem solution. For this purpose a recently introduced complex Jacobi iterative (CJI) method [4] is proposed for the solution of WA beam propagation and shown to be highly efficient.

Since the utility of the CJI technique depends mostly upon its execution speed in comparison with the traditional direct matrix inversion (DMI) method, we also present several speed comparisons. Numerical implementations are carried out for 3D optical waveguide structures.

Results

Via a quantitative comparison of runtimes between the traditional DMI and the new CJI method for 3D WA beam propagation, it is convincingly demonstrated that the CJI method is very competitive for demanding problems. The resulting runtimes of these methods for 3D optical waveguide structures are listed in Table 1.

TABLE 1
Quantitative comparison of runtimes of the DMI and the CJI for WA beam propagation based on Hadley (1,1) and KP(1,1) approximant in waveguide (WG) structure

Method \ Structure		3D Y-branch rib WG
DMI		5462.0 s
CJI	Hadley(1,1)-based WA-BPM	70.0 s
	KP(1,1)-based WA-BPM	46.9 s

References

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