Extending the Complex Jacobi Iteration method to simulate
Kerr non-linear effects

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In this paper we present a numerical method to simulate an area containing materials with a
non-linear third order Kerr effect. This method is based on an extension of the recently introduced
complex Jacobi Iteration method.

Keywords: numerical modelling, complex Jacobi iteration, non-linear, Kerr effect, PML

Achieving all-optical functionality in integrated components requires materials which exhibit non-linear effects. The almost instantaneous Kerr effect with its intensity dependent
index change is considered a promising route to achieve fast optical switching functionality. Simulating a Kerr non-linear optical component in the frequency domain results in numerically
solving a slightly adapted Helmholtz equation.

The recently introduced Complex Jacobi Iteration method [1] is a fast method to solve the linear Helmholtz equation. Starting with a discretized grid and Helmholtz operator, this
method finds a solution by an iterative process. Each iteration step the calculated fields are
refined until a desired error is achieved.

To model non-linear Kerr effects, an extra step is introduced in the iterative update scheme. At each iteration step a new refractive index is calculated based on the found field-intensity. A
relative error smaller than 1.e-8 can be achieved.

Fig 1 shows the absolute E-field of a propagating soliton in an uniform material. The
maximum relative index change - at the center of this soliton - is 15%. The use of a material with
high non-linear Kerr effect only results in a slight increase of iteration steps. Good absorption
at the boundaries is achieved by using perfectly matched layers (PML). The implementation
of these PML is done with complex coordinate stretching.

![Field Injection](image)

(a) linear material

![Non-linear Material](image)

(b) non-linear material ($\chi^3 = 6.0 \frac{pm^2}{V^2}$)

Fig. 1. Injecting a Gaussian bundle in a non-linear Kerr material results in a soliton.

($\epsilon = 12.96 - 0.001j$, $E = 1.0e^{\frac{-x^2}{20.0^2}} \frac{Y}{\mu m}$)

Parts of this work has been performed in the context of the Belgian IAP Photon network. Parts
of this work has been performed in the European FP6-IP-OLLA project.