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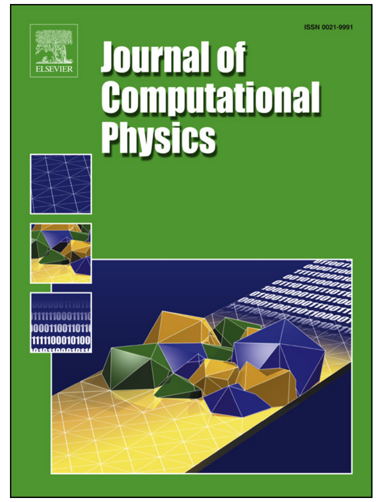

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Yongle Hao, Fengdai Kang, Jingzhi Li, Kai Zhang

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Computation of moments for Maxwell's equations with random interfaces via pivoted low-rank approximation

Yongle Hao[a], Fengdai Kang[b], Jingzhi Li[c,*], Kai Zhang[a,*]

[a] *Department of Mathematics, Jilin University, Changchun, Jilin 130023, P. R. China.*
[b] *Department of Mathematics, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong SAR.*
[c] *Department of Mathematics, Southern University of Science and Technology, Shenzhen, 518055, P. R. China.*

Abstract

The aim of this paper is to compute the mean field and variance of solutions to three-dimensional Maxwell's equations with random interfaces via shape calculus and pivoted low-rank approximation. Based on the perturbation theory and shape calculus, we characterize the statistical moments of solutions to Maxwell's equations with random interfaces in terms of the perturbation magnitude via the first order shape-Taylor expansion. In order to capture oscillations with high resolution close to the interface, an adaptive finite element method using Nédélec's third order edge elements of the first kind is employed to solve the deterministic Maxwell's equations with the mean interface to approximate the expectation of solutions. For the second moment computation, an efficient low-rank approximation of the pivoted Cholesky decomposition is proposed to compute the two-point correlation function to approximate the variance of solutions. Numerical experiments are presented to demonstrate our theoretical results.

Keywords: Maxwell's equations, random interfaces, shape calculus, edge element, low-rank approximation

2010 MSC: 65M60, 65N30, 35Q60, 65C05

1. Introduction

The interaction of electromagnetic waves with physical objects plays important roles in science and engineering, such as wide band antennas, telecommunication chips and remote sensing, etc. Singularities or oscillations arise when electromagnetic fields impinge at the corners and edges of geometrical domains as well as on the interfaces between different media. Interested readers may refer to [11, 13, 23, 41, 43] and references therein for relevant mathematical models governed by Maxwell's equations with material interfaces, which is of immense interest in the computational simulation in nano-physics, biology and chemistry, where one has unsharp interfaces like rough cross sections, cell membranes and molecular surfaces for instance. In practical applications, the interfaces of different materials are almost never exactly known beforehand, which requires the

*Corresponding author
Email addresses: haoyl1009@mails.jlu.edu.cn (Yongle Hao), fdkang2@cityu.edu.hk (Fengdai Kang), li.jz@sustc.edu.cn (Jingzhi Li), kzhang@jlu.edu.cn (Kai Zhang)