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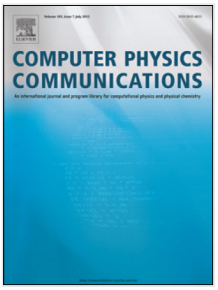

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A Hybrid Jacobi-Davidson Method for Interior Cluster Eigenvalues with Large Null-Space in Three Dimensional Lossless Drude Dispersive Metallic Photonic Crystals

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Abstract

We study how to efficiently solve the eigenvalue problems in computing band structure of three-dimensional dispersive metallic photonic crystals with face-centered cubic lattices based on the lossless Drude model. The discretized Maxwell equations result in large-scale standard eigenvalue problems whose spectrum contains many zero and cluster eigenvalues, both prevent existed eigenvalue solver from being efficient. To tackle this computational difficulties, we propose a hybrid Jacobi-Davidson method (hHybrid) that integrates harmonic Rayleigh-Ritz extraction, a new and hybrid way to compute the correction vectors, and a FFT-based preconditioner. Intensive numerical experiments show that the hHybrid outperforms existed eigenvalue solvers in terms of timing and convergence behaviors.

Keywords: Three-dimensional dispersive metallic photonic crystals, clustered eigenvalues, zero eigenvalues, hybrid Jacobi-Davidson method, preconditioner

1. Introduction

Photonic crystals have been shown to exhibit electromagnetic propagation properties that lead to various potential applications [29, 32, 41, 43]. Dispersive metallic photonic crystals with face-centered cubic (FCC) lattices are of great interest in fundamental research and application developments. One attractive attribute of such structures is that their band structures are quite different from the band structures in dielectric photonic crystals [35, 38, 39, 40, 54]. For example, an FCC lattice consisting of dielectric spheres embedded in a dispersive background material can demonstrate a high cutoff frequency [19].