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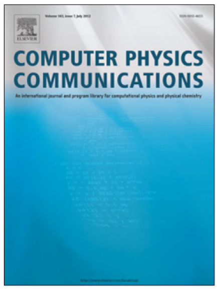

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Zi He, Ru-Shan Chen

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Frequency-domain and Time-domain Solvers of Parabolic Equation for Rotationally Symmetric Geometries

Zi He and Ru-Shan Chen*

Nanjing University of Science and Technology, Nanjing, 210094, China
Corresponding author. Tel.: +86 02584315195.
E-mail address: eerschen@njust.edu.cn (Ru-Shan Chen).

Abstract

Both the frequency-domain and the time-domain body of revolution parabolic equations (FD-BoR-PE, TD-BoR-PE) are derived in this paper. By taking advantage of the rotationally symmetrical property, better performance of the PE method can be achieved for the analysis of bodies of revolution (BoRs). In each transverse plane, only the unknowns of a line, which starts from the centre and passes through the node on the generatrix, need to be calculated. Then the unknowns for each transverse plane can be obtained by Fourier series summation for each Fourier mode and the calculation can be taken with a marching manner along the paraxial direction of the PE. As a result, the computational resources can be reduced greatly when compared with the traditional CN, alternating direction implicit (ADI) and alternating group explicit (AGE) finite difference schemes. Both the propagating and scattering problems are given to demonstrate the validity and efficiency of the proposed methods.

Key Words

EM scattering, Parabolic equation, Frequency-domain, Time-domain, Body of revolution.

1. Introduction

Rotationally symmetrical geometries play an important role in the area of computational electromagnetics, such as radome, reflector antenna and so on. This type of body of revolution (BoR) is widely studied by many scholars in both frequency and time domain [1-7]. In [1-4], the radiation and scattering from BoRs are analyzed in frequency domain by using the integral equation. Since the marching-on-in-time (MOT) method cannot take advantage of the rotationally symmetrical property for sub-domain temporal basis functions [9], the transient electromagnetic analysis are taken by the marching-on-in-degree (MOD) method in the time domain [5-8]. The BoR basis functions are only defined on the generatrix and can be expanded with Fourier series along the azimuthal direction. As a result, both the memory requirement and CPU time can be saved significantly. Moreover, a lot of fast algorithms are introduced to accelerate the calculation to some reasonable extent [6, 10-13], such as the low rank compression methods [6, 10, 12], the fast Fourier transform (FFT) [11], and the equivalent dipole method (EDM) [13]. However, a huge number of computational resources are needed with the electrical size increasing for integral equation methods. Therefore, it has a great significance to develop the technique of dimension reduction.

Parabolic equation (PE) method has been widely used to propagating and scattering problems for its simplicity and high efficiency [14-19]. The PE is an approximation of the wave equation and expanded with Taylor expansions of the pseudo-differential operator. By using the finite difference scheme, the calculation can be taken plane by plane in a marching manner along the paraxial direction. Therefore, higher efficiency can be obtained by the PE