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The application of a modified method of discrete sources for solving the problem of wave scattering by group of bodies

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Abstract

A new universal and effective algorithm for solving the problems of wave diffraction on complicated structures composed of bodies of revolution is presented. The method is applied to diffraction on a group made of two impedance bodies of revolution. The method permits to get the pattern and the field with high accuracy.

Keywords: Scattering problems; Discrete sources method; Analytical continuation of scattered field; Group of bodies

1. Introduction

The modified method of discrete sources (MMDS), offered in works [1,2], has been subsequently applied to solving a wide class of problems of the theory of diffraction, and high efficiency of the method has been demonstrated in all cases [1–4]. The main idea of the method consists in a uniform way of construction of the carrier of discrete (auxiliary) sources by means of analytical deformation of the border of a scatterer. Thus the a priori information on properties of analytical continuation of diffraction field inside the scatterer [5,6] is materially used.

The problem of wave diffraction on a closely located group of two impedance bodies of revolution is considered in this paper. In consequence of diffraction interaction of the bodies, the picture of arrangement of singularities of analytical continuation of wave field inside each scatterer [5] can significantly differ from that which takes place in the case of a single body. In the case of close location of scatterers, singular points start "to be multiplied", i.e. singularities inside one body generate singularities inside the other. In this paper, further modification of MMDS is realized. We call this modification MMDS(+). This makes the method efficient for solving the problem of wave diffraction on a closely located group of bodies. The essence of this modification is that the carrier of discrete sources for each body is constructed using the usual scheme of MMDS. However, sources surrounding singular points, which appear because of the interaction between scatterers, are appended in addition to the basic sources. As a result, the accuracy of calculations increases approximately for order at the same sizes of corresponding algebraic systems. In some instances, coordinates

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of singularities of scattered field can be found analytically; however, in the general case, numerical calculations are necessary. In this work, the effective numerical algorithm to decide on singularities coordinates based on continuation by a parameter is offered.

2. Statement of the problem

Let the group of two bodies of revolution be located on one axis and bounded by surfaces S_1 and S_2. We choose the system of coordinates so that axis z coincides with the axis of revolution of the bodies (see Fig. 1). Assume, that impedance boundary condition on surfaces of scatterers satisfies

$$\vec{n}_p \times \vec{E} = Z_p \vec{n}_p \times (\vec{n}_p \times \vec{H}), \quad p = 1, 2. \tag{1}$$

where Z_p is impedance on the surface S_p and $\vec{n}_p$ is the outward normal. The secondary field, everywhere outside the domains of the bodies, satisfies the homogeneous Maxwell equations:

$$\nabla \times \vec{E}^1 = -\mathrm{i}k\eta \vec{H}^1, \quad \nabla \times \vec{H}^1 = \frac{\mathrm{i}k}{\eta} \vec{E}^1, \tag{2}$$

where $k = \omega\sqrt{\varepsilon\mu}$ is wave number, $\eta = \sqrt{\mu/\varepsilon}$ wave impedance of the medium. Besides, the secondary field satisfies the attenuation condition at infinity:

$$\left(\vec{E}^1 \times \frac{\vec{r}}{r}\right) + \eta \vec{H}^1 = o\left(\frac{1}{r}\right), \quad \left(\vec{H}^1 \times \frac{\vec{r}}{r}\right) - \frac{1}{\eta}\vec{E}^1 = o\left(\frac{1}{r}\right), \quad r \to \infty. \tag{3}$$

3. Derivation of the main relations

Let us introduce the local systems of coordinates connected with each scatterer. We choose the origins of the systems inside surfaces S_1 and S_2 (see Fig. 1). The secondary field is equal to the sum of the fields scattered by each body:

$$\vec{E}^1 = \frac{\eta}{i} \nabla_p \times \nabla_p \times \sum_{p=1}^{2} \int_{\Sigma_p} \vec{J}_p G_p \, \mathrm{d}\sigma, \tag{4}$$

$$\vec{H}^1 = k \cdot \nabla_p \times \sum_{p=1}^{2} \int_{\Sigma_p} \vec{J}_p G_p \, \mathrm{d}\sigma, \tag{5}$$

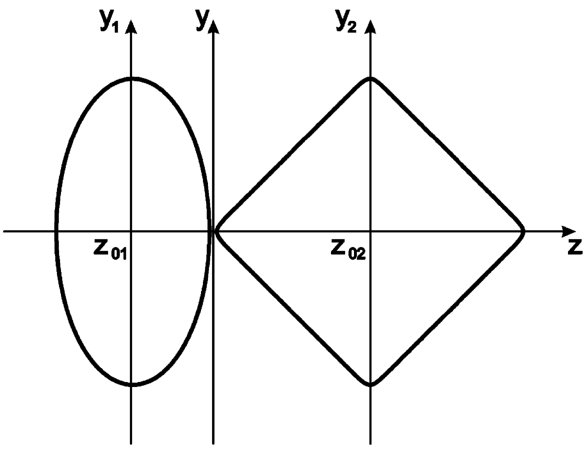

Fig. 1. Geometry of the problem.