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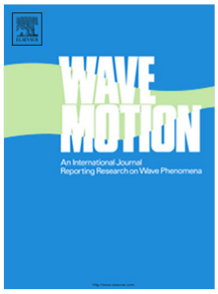

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Hélène Barucq, Juliette Chabassier, Ha Pham, Sébastien Tordeux

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Numerical robustness of single-layer method with Fourier basis for multiple obstacle acoustic scattering in homogeneous media

Hélène Barucq[1,2], Juliette Chabassier[1,2], Ha Pham[1,2], Sébastien Tordeux[2,1]

Abstract

We investigate efficient methods to simulate the multiple scattering of obstacles in homogeneous media. With a large number of small obstacles on a large domain, optimized pieces of software based on spatial discretization such as Finite Element Method (FEM) or Finite Difference lose their robustness. As an alternative, we work with an integral equation method, which uses single-layer potentials and truncation of Fourier series to describe the approximate scattered field. In the theoretical part of the paper, we describe in detail the linear systems generated by the method for impenetrable obstacles, accompanied by a well-posedness study. For the numerical performance study, we limit ourselves to the case of circular obstacles. We first compare and validate our codes with the highly optimized FEM-based software Montjoie. Secondly, we investigate the efficiency of different solver types (direct and iterative of type GMRES) in solving the dense linear system generated by the method. We observe the robustness of direct solvers over iterative ones for closely-spaced obstacles, and that of GMRES with Lower-Upper Symmetric Gauss-Seidel and Symmetric Gauss-Seidel preconditioners for far-apart obstacles.

Keywords: Multiple scattering, small obstacle acoustic scattering, single layer methods, preconditioning in multiple scattering.

1. Introduction

In this paper, we study efficient numerical methods to simulate the multiple acoustic scattering by a large number of small obstacles in a two-dimensional large and homogeneous media. In the presence of obstacles, an incident wave $u^{\mathbf{I}}$ is scattered, and the total field $u^{\mathbf{T}}$ is given as a superposition of the incident field $u^{\mathbf{I}}$ and the scattered one denoted by u, i.e. $u^{\mathbf{T}} = u^{\mathbf{I}} + u$, see Figure 1.

Email addresses: helene.barucq@inria.fr (Hélène Barucq), juliette.chabassier@inria.fr (Juliette Chabassier), ha.howard@inria.fr (Ha Pham), sebastien.tordeux@inria.fr (Sébastien Tordeux)

[1] INRIA Bordeaux Sud-Ouest Research Center. Team Project Magique-3D.

[2] Université de Pau et des Pays de l'Adour, France.