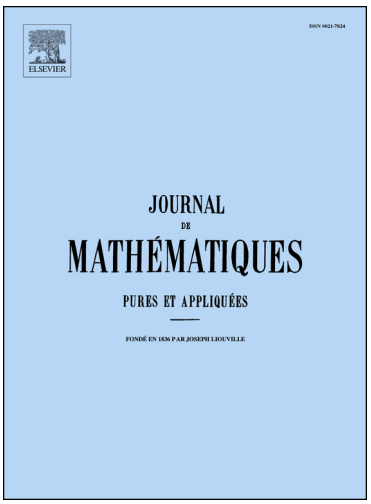

Super-resolution in imaging high contrast targets from the perspective of scattering coefficients

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Super-resolution in Imaging High Contrast Targets from the Perspective of Scattering Coefficients

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Abstract

In this paper we consider the inverse scattering problem for high-contrast targets, and analyze mathematically the experimentally observed phenomenon about super-resolution in imaging the shapes of these targets. In particular, super-resolution at specific high contrast values is justified based on the novel concept of scattering coefficients and several important implications (given by two main theorems, Theorems 4.6 and 4.9). This is the first time that a mathematical theory of super-resolution is established in the context of imaging high-contrast inclusions. We shall also illustrate our main findings with a variety of numerical examples. These findings may help develop resonant structures for resolution enhancement.

Keywords: inverse scattering, super-resolution, scattering coefficients
2010 MSC: 35B30, 35R30

1. Introduction

The aim of this work is to mathematically investigate the mechanism underlying the experimentally-observed phenomenon of super-resolution in reconstructing targets of high contrast from far-field measurements. Our main focus is to explore the possibility of breaking the diffraction barrier from the far-field measurements using the novel concept of scattering coefficients [1, 2, 3]. This diffraction barrier, referred to as the Abbe-Rayleigh or the resolution limit, places a fundamental limit on the minimal distance at which we can resolve the shape of a target [4, 5]. It applies only to waves that have propagated for a distance substantially larger than its wavelength [6, 7].

Since the mid-20th century, several approaches have aimed at pushing this diffraction limits. Resolution enhancement in imaging the target shape from far-field measurements can be achieved using sub-wavelength-scaled resonant media [8, 9, 10, 11, 12, 13], single molecule imaging [14] and using plasmonic particles [15]. Another innovative method to overcome the diffraction barrier has been proposed after some experimental observations in [16]. In their work, resolution enhancement in shape reconstruction of the inclusion was experimentally shown when the contrast value is very high. In the reconstructed images

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