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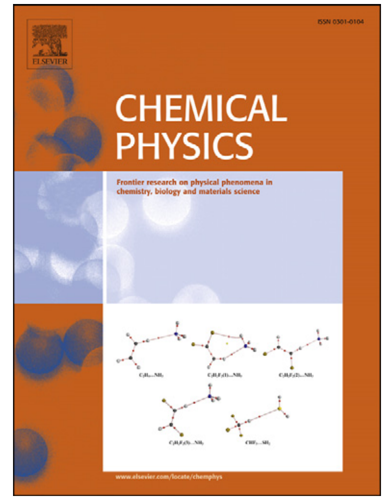

Calculating scattering cross sections in the near field: analytic proof and numerical verification

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Calculating scattering cross sections in the near field: analytic proof and numerical verification

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The scattering cross section (SCS) is a key property in plasmonic studies that carries valuable information on the scattering dynamics. Due to the complexity of fields and the interference from evanescent waves in the near-field region, the SCS is currently calculated in the far-field, which makes the computation costly. In this study we prove analytically that the total SCS is independent of the distance between the closed surface used to calculate the SCS and the scattering structure, hence introducing a numerically inexpensive approach to computing the total SCS, based solely on near-field information. We carry out also two numerical tests of this analytical proof in discretized spaces, verifying its applicability in computations.

I. Introduction

The scattering cross section (SCS) spectrum plays a central role in scattering theory of light and particles. Specifically, in the context of nanoplasmonics[1], the SCS spectrum characterizes the position, intensity, and broadening of plasmon resonances, which contain valuable information regarding the scattering dynamics and the material properties. The SCS spectra of highly symmetric structures, such as spheroids, cylinders, and shells can be calculated analytically with the Mie theory[2-5]. The SCS spectra of complex scattering structures, however, need to be calculated numerically.

Bohren and Huffman[3] define the SCS as the surface integral of the Poynting vector of the scattered fields over a sphere surrounding the scattering structure, divided by the incident irradiance

$$C = \frac{1}{I}\int_A \mathbf{S}\cdot\mathbf{n}\,dA, \qquad (1)$$

where $\mathbf{S}$ is the Poynting vector, $\mathbf{n}$ is the normal vector on the surface, A is the surrounding sphere, I is the incident irradiance, and C is the SCS. The most important step in calculating the SCS is calculating $\mathbf{S}$ on the surface A. It is commonly believed that the Poynting vector $\mathbf{S}$ in (1) needs to be calculated in the far-field[6-8], where the electromagnetic wave behaves much more regularly than in the near-field. First, the SCS is only defined for the radiating fields, but not for the near-field evanescent fields created

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