Computational analysis of scattering by penetrable oblate spheroids using a model of dipoles located in complex space

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Abstract: The recently introduced extension of the current-model technique, which has facilitated a more efficient solution to problems of metallic scatterers whose periphery contains a variety of length-scales features, is applied to analyse scattering by penetrable bodies of similar shape. In the extension of the current-model technique, the coordinates of part of the elemental source centres assume complex values. In this way, the fields radiated by these sources have a beam-shaped pattern and they can better span the field scattered by the smooth parts of the air-body interface. The coordinates of the other source centres retain their conventional real values or have only a relatively small imaginary constituent. The fields radiated by these sources are used to span the field scattered by the rapidly varying parts of the air-body interface. The suggested approach is applied to analyse electromagnetic scattering by a penetrable oblate spheroid. It is found to render the solution computationally more effective at the expense of only a slight increase in its complexity.

1 Introduction

In recent years, the use of models of fictitious currents has proven to be an efficient computational technique for analysing a variety of three-dimensional time-harmonic electromagnetic scattering problems [1, 2]. As in the related generalised multipole technique (GMT) [3, 4], the problem in the current-model technique is formulated not in terms of equivalent current distributions applying standard formulations, but in terms of fictitious simple sources; simple in the sense that their fields are analytically derivable in the region of interest. This kind of approach offers a few attractive features. First, the intensive field calculations involved are made simple by avoiding surface integrations. Second, the freedom in the choice of source locations permits fitting of the actual fields on the boundaries as per requirement by means of smooth field functions. Third, the inaccuracies in the approximate boundary field tend to be globally correlated, and an application of the boundary conditions in the simple point-matching sense is sufficient. In the current-model solution presented in Reference 1, the simple sources are Hertzian dipoles located on suitably chosen mathematical surfaces which are displaced from the physical ones, while in the various GMT solutions discussed in Reference 4 these sources are multipoles centred at multiple origins. In some other current-model solutions there have been preferences for other sources. Specifically, in the case of periodic structures, spatially diffused sources with analytically derivable fields have been used [5, 6].

This paper takes a step forward in extending the current-model technique to handle problems of electromagnetic scattering by objects that contain a variety of length-scales ranging from subwavelength to several wavelengths. To solve problems of this kind, one can of course combine the current-model technique with other numerical and asymptotic methods to form a hybrid method which possesses the required flexibility. In such a hybrid method, the effect of the rapidly changing small-scale features can be accounted for by using the current-model technique, while the smoothly varying large-scale features can be analysed by a high-frequency asymptotic technique such as a geometrical theory of diffraction. However, in this paper we further investigate the more promising way of accommodating large-scale variations, which has been applied recently by the authors to analyse three-dimensional acoustic scattering by pressure-release bodies [7] and electromagnetic scattering by perfectly conducting bodies [8, 9]. The basic principle is in tune with the current-model technique's general idea of using simple sources, the fields of which are analytically derivable. It amounts to letting the originally real coordinates of some of the source centres be analytically continued to complex values [10–12]. A similar approach has also been applied recently in a GMT solution for scattering by three-dimensional perfectly conducting bodies [13]. Positioned in complex space, the simple current sources produce in the real space beam-shaped fields that are nearly Gaussian but have equivalent aperture distributions of finite extent. Hence, these fields can be more effectively approximate the scattering from the smooth expanses of the object rendering the solution accurate with a reasonable accuracy.