A spectral-domain method for the electromagnetic scattering from a multilayered sphere buried in a stratified medium

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In this work we present a rigorous method to analyze the electromagnetic scattering of an elliptically polarized plane wave by a multilayered sphere buried in a dielectric stratified medium (Fig. 1). The interaction of the electromagnetic radiation with the stratified material is taken into account by means of the transfer-matrix approach: in this way we can consider the stratified medium as an effective single interface. We assume that all media are linear and lossless.

All the electromagnetic fields are expanded in series of spherical vector harmonics. To solve the problem, we decompose the electric field into different contributions. We consider the incident field E_i, the reflected field E_r and the transmitted field E_t by the stratified medium in the absence of the sphere. Moreover, we consider the field scattered by the sphere E_s and the *N*-fields within the external sphere E_{spj} with $j = 1,\ldots, N$. Furthermore we consider the scattered-reflected field E_{sr} and the scattered-transmitted field E_{st} due to the reflection and transmission of E_s by the stratified medium, respectively. The transmitted field through the stratified medium is obtained by means of the effective transmission coefficient. This field is scattered by the multi-concentric sphere and the scattered field interacts again with the stratified material. The scattered-reflected and scattered-transmitted fields by the layered medium are computed by exploiting the plane-wave spectrum of the scattered field, considering the reflection and transmission of each elementary plane wave by the effective interface. The boundary conditions imposition on the spheres' surfaces leads to a linear system, and then to a square matrix, that returns the unknown coefficients of the problem.

A numerical code has been implemented to compute the field all-over the space. In order to compute the scattered fields, a truncation criterion has been proposed for the numerical evaluation of the series.

Finally, to validate the presented method, comparisons between the results of the proposed code and those of simulations with a commercial software based on the Finite Element Method, have been implemented, showing very good agreement. In particular we consider the real and imaginary parts of the total scattered field by the sphere in the third medium as a function of the frequency. Moreover, we consider the total scattered electric field in the third medium on a line along the *x*-axis, for a given frequency.

The generality of the presented method allows its application to several fields of engineering, as detection of buried objects, biomedical sensing problems, metamaterial analysis, and microscopy.