A Numerical Method for Rough-Walled Waveguides

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Propagation in rough-walled waveguides has received a great deal of attention in previous years for many applications in electromagnetics, acoustics, and elasticity. By in large however, little has been done in the way of numerical methods to deal with such problems. With the increased interest in applications involving wave propagation in tunnels, caves, and even the ‘urban canyon,’ the need for such methods is becoming even more pressing. The purpose of this paper is to apply one particularly successful single-wall method to setting up a numerical scheme for dealing with wave propagation in a parallel plate waveguide.

To simplify the illustration, the problem is taken to be a source exciting the interior of a waveguide formed by two perfectly conducting parallel planes located at $z = 0$ and at $z = a$. The source is assumed to be a line source of current extending to infinity along the y-coordinate and at ($x = 0$, $z = 0$). The waveguide walls are further taken to be rough in the x-direction with the roughness forming a stochastic process having zero mean and a specified probability density function and spectrum. The goal of the research is to find an expression for the scalar field strength at any position x down the rough-walled waveguide. Having found an appropriate numerical method for predicting the field for any realization of the roughness process, Monte Carlo techniques may then be used to generate the statistics of the field at any point in the guide.

The approach we investigate is the *Method of Ordered Multiple Interactions (MOMI),* or also called the *Forward-Backward Method,* which has proven to be very useful for calculating the scattering by an infinite, mean planar, rough surfaces. With the introduction of the second rough wall, there are two multiple scattering processes in force. The first is due to the wall roughness which gives rise to the interaction of one part of the wall with another. The second is the wall-to-wall scattering that reduces to a simple reflection process in the absence of the roughness. MOMI is a method for essentially re-summing the most important orders of roughness induced multiple scattering and doing it in a manner that easily computed with minimum storage requirements. The addition of the second rough wall complicates the simplicity of the basic MOMI method, but it is shown herein how this may be recovered. It is demonstrated how the important orders of roughness and wall-to-wall induced multiple scattering may be reordered and re-summed into a form that retains the easy-to-calculate and minimum storage attributes of the original MOMI. It is particularly easy to see how robust the approach is when the roughness is small in amplitude. Furthermore, the MOMI approach produces a result that is also amenable to application of the fast multipole technique for an additional reduction in computational time.