Application of Krylov Subspace Iterative Methods to Waveguide Scattering Problems

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For a waveguide that is non-uniform in the propagation direction, a central problem is to determine its re°ected and transmitted waves for a given incident wave. It is important to develop e± cient numerical schemes for such a waveguide scattering problem. For optical waveguides and time-harmonic waves with only a single longitudinal re°ecting interface, a popular method uses an iterative method together with some complex coe± cient rational approximations for the related square root operators. We demonstrate that when the original iterative scheme based on the Neumann series is replaced by a modern Krylov subspace method, a much faster convergence is possible, even when the original Neumann series diverges. In the case of multiple re°ecting interfaces (in the propagation direction), one can generalize the Bremmer coupling series originally formulated for the one-dimensional Helmholtz equation. Nevertheless, the Bremmer coupling series is only a special case of the Neumann series, and we also obtain a much more e± cient scheme when it is replaced with a Krylov iterative method. Since waveguides with piecewise homogeneous structures are important for optical engineering, we present our scheme in the discrete form. Rational approximations are used to approximate the square root and the propagation operators as in one-way beam propagation methods.